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PROCEEDINGS

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE DRIGGS-SCHROEDER SYSTEM OF RAPID-FIRE GUNS.

By Lieut. W. H. Driggs, U. S. Navy.

Having been requested by the Naval Institute to contribute an article under the above title, I have compiled such data and records as may be of interest to its readers. It has been my intention to avoid, as far as possible, drawing any comparisons between this and any other special system. As this publication circulates mainly among men familiar with the results obtained from other guns of this class, comparisons can be easily made from the data here given.

It may fairly be said that the rapid-fire gun is a new improvement in ordnance, as the guns ordered for the Chicago, Boston, Atlanta, and Dolphin were the first ordered by any government. Other nations soon followed, and some had guns of this class actually in service before the United States, owing to the fact that these ships were not ready to receive them for some time after the order was placed. From that day to this the importance of this class of ordnance has gradually increased, and is likely to increase still further. From being present only in the secondary batteries it has found its way into the main

battery, and its caliber has been expanded from that of the 6-pounder to that of the 100-pounder.

To discuss the advantages of this class of ordnance in general would occupy more space than allowed to an article of this kind. I will therefore confine myself to describing the particular design of the Driggs-Schroeder.

At the time this gun was designed there was no place in the country where the Navy could obtain ordnance of this type. Even had the Department been inclined to purchase its guns from foreign countries, Congress effectually forestalled this by an act requiring the new ships to be throughout of domestic manufacture. There was, therefore, no course open except to induce manufacturers to start the building of these guns in the United States.

As the most successful gun of that day was the Hotchkiss, that company was offered an order for some 94 guns and a considerable amount of ammunition to induce them to build in this country. This order was accepted and the manufacture of the guns placed in the hands of the Pratt & Whitney Co., of Hartford, the ammunition being made by the Winchester Arms Co., of New Haven. About the time this order was placed with the Hotchkiss Co., an experimental 3-pdr. Driggs-Schroeder gun was made and submitted for trial at Annapolis. The results were all that had been anticipated, but the authorities hesitated to endorse the system until after the successful trial of a larger caliber. A 6-pounder was therefore built, and after successful tests, during which some 150 rounds were fired, under all conditions of service, an order was placed with the Driggs Ordnance Co. (which had been organized after the trial of the experimental 3-pdr.) for 20 guns (10 3-pounders and 10 6-pounders). This order was soon followed by an order for 30 more 6-pounders, on condition that the first gun delivered under the first order should pass a successful test of 200 rounds in 4 consecutive hours. This having been accomplished without any failure whatever, an order was placed with the Driggs Ordnance Co. for 75 additional 6-pounder guns. The experimental 6-pounder, after passing through the tests at Annapolis, was sent to Bridgeport for testing ammunition, and has now fired upwards of 400 rounds, without having any repairs whatever put upon the mechanism. The other 6-pounder gun tested at Annapolis, as mentioned above, has now fired about 350 rounds. No repairs have been put upon it, except the replacing of a small spring in the handle, which was injured in transporting the gun.

A 3-pounder gun has just passed through a very severe trial in England, conducted by the English government. In the preliminary test for strength, etc., the pressures and velocities reached were as follows:

Vel.	2005 f. s.	Pressure	12.8 tons.
"	2089 "	"	19.7 "
"	not taken	"	16.3 "
"	2121 "	"	16.7 "
"	2142 "	"	18.8 "
"	2165 "	"	19.2 "

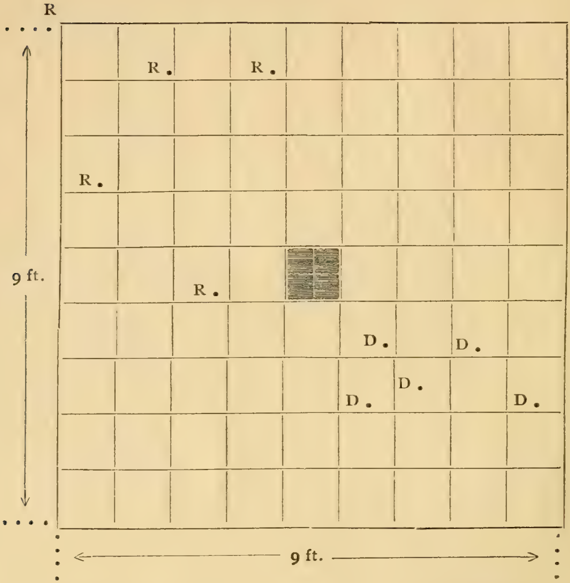
The main object of this part of the trial being for strength of gun, the powder charge was set to produce high pressures without regard to velocities. With suitable powder, the gun will give 2100 f. s. with a pressure under 15 tons. The breech-closure worked smoothly throughout. Tests were then made to see the effect of defective ammunition. For this purpose eight split cases and three pierced primers were the results out of 20 rounds. We believe this is the most severe test a gun of this class has ever been put to, but it can be said also to the credit of the piece, that with the exception of one misfire (which occurred after one of the blow-backs through the primer, and this cap was exploded on second trial), that the gun worked perfectly throughout. We mention this test particularly, as rivals have claimed that with blow-backs or high pressures the breech-block will stick. Four Driggs-Schroeder guns have been subjected to official tests, all of which have been satisfactory, and in no instance has the breech mechanism stuck.

During the last test in England a 3-pounder Driggs-Schroeder was brought in competition with a 3-pounder of a different system. The competition was on velocity, accuracy and jump. The velocities were as follows on first series:

Driggs-Schroeder.		Rival Gun.	
I. V.	1859 f. s.	I. V.	1843 f. s.
"	1856 "	"	1848 "
"	1893 "	"	1840 "
"	1861 "	"	1844 "
"	1900 "	"	1820 "
Mean	$1873\frac{4}{5}$ "	Mean	1839 "

The test for accuracy consisted of five rounds each at a target 9 feet square, distant 500 yards.

TARGET.



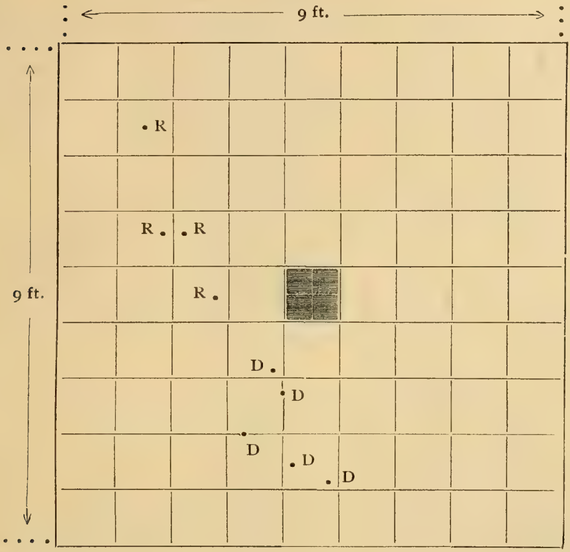
R = Rival gun. D = Driggs-Schroeder.

NOTE.—The fifth shot of the rival missed the target entirely.

Second Series.

Driggs-Schroeder.			Rival Gun.		
I. V.	1900	f. s.	I. V.	1821	f. s.
"	1862	"	"	1807	"
"	1852	"	"	1786	"
"	1862	"	"	1809	"
"	1865	"	"	1805	"
Mean	$1868\frac{1}{5}$	"	Mean	$1805\frac{3}{8}$	"

TARGET.



NOTE.—First shot of rival missed the target. Target distant 500 yards.

It will be seen that in both of these tests the Driggs-Schroeder was more accurate and gave higher velocities than its rival. The loading was the same in each case and the guns handled by the same crew. The Driggs-Schroeder gun is some 30 pounds lighter than its competitor, and besides has a greater strength of walls.

STRENGTH OF WALLS.

In all gun construction this is of prime importance, but it is doubly so in a gun to be handled in the manner of a rapid-firing arm, as, to make good practice, the crew must have confidence in the strength of the piece.

For this reason great care has been used in selecting the proper methods. The old style of forging the trunnions on the jacket was discarded, for the reason that a forging made in this way is not reliable, and, besides, that it forms entering angles that weaken the

construction. The forgings for the Driggs-Schroeder guns were therefore kept cylindrical throughout all the portion of the gun under the powder pressure. This avoids as far as possible abrupt angles and makes a uniform and homogeneous forging, as the whole length of each piece has the same amount of work put upon it in the forge, which is not the case in a forging that has to be forged cylindrical for a part of its length and then the trunnions drawn out at right angles to it.

The general construction of the gun is as follows:

The jacket, in two parts, the forward one of which is termed a sleeve, is shrunk upon the tube, the two parts being connected under the trunnion-band by the screw-thread of the latter. A jog in the adjacent surfaces of tube and sleeve transfers to the trunnions the thrust imparted by the rifling. The breech mechanism is contained in the rear of the jacket, which forms a natural housing and protection for the same.

The trunnion-band is not shrunk on the gun, but simply screwed on tight and pinned to prevent turning. In the guns built for the navy it has been omitted entirely, the gun screwing directly into the sleeve of the recoil mount.

The construction of all the guns is the same in principle. There is a slight change made in the 1-pounder, for the reason that it was intended to shift this gun about and to use it as a subcaliber piece for the large broadside guns. It was therefore thought best not to trust to the mounting to lock the tube and jacket, so for this purpose the sleeve was both screwed and shrunk on.

The general construction of the 6-pounder is shown in Plate A.

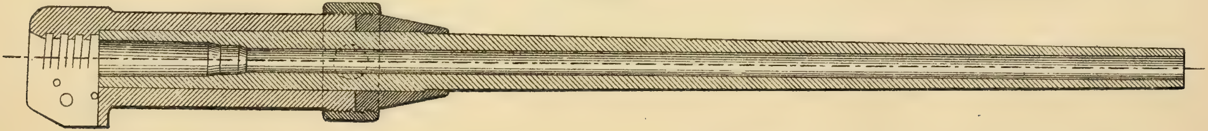
In favor of the guns themselves, independent of mechanism, attention is invited to their weight and length, high grade of steel, and the strength of the gun. Their length of bore is 45 calibers—longer, we believe, than any guns of their weight and strength in the world, and certainly longer than any guns of their weight in the United States.

The steel used is of the best quality, furnished by the Midvale Steel Co. and the Bethlehem Iron Co. The records of the Government Inspectors at these works show the steel used in the forgings to possess the following qualities:

Tensile strength, 90,000 to 135,000 pounds per square inch.
Elastic strength, 50,000 to 80,000 " " "
Elongation, 15 to 30 per cent of its length.
Contraction, 20 to 50 " " area.

PLATE. A.

6 Pounder.



The Driggs-Schroeder guns are shrunk together with shrinkages computed from the following formulæ, and each gun has the shrinkages computed for it according to the characteristics of the metal.

FORMULÆ.

$$P_1 = \frac{3\theta_1(R_2^2 - R_1^2)}{4R_2^2 + 2R_1^2},$$

$$\left.\begin{aligned} P_0^{(1)} &= \frac{3\theta_0(R_1^2 - R_0^2) + 6R_1^2P_1}{4R_1^2 + 2R_0^2}, \\ P_0^{(2)} &= \frac{3\rho_0(R_1^2 - R_0^2) + 2R_1^2P_1}{4R_1^2 - 2R_0^2}, \end{aligned}\right\} \text{Using the one that gives the less value.}$$

$$\varphi_1 = \frac{1}{E}\left[\frac{(4R_0^2 + 2R_1^2)P_1 - 6R_0^2P_0}{3(R_1^2 - R_0^2)} + \theta_1\right],$$

$$S_1 = \varphi_1 \times D_1.$$

These formulæ are deduced from those found in Notes on the Construction of Ordnance No. 35, Captain Rogers Birnie, Jr., U. S. A.; the shrinkages being in terms of the pressures in a state of action, and on the hypothesis that the modulus of elasticity is constant and equal to 29,000,000 pounds. The elastic strength of compression is assumed to be equal to the elastic strength of tension.

To guard against the adoption of a shrinkage which would cause permanent compression of the bore, the variations of pressure in the states of rest and of action are computed by the formula:

$$p_1 = -\frac{R_0^2(R_2^2 - R_1^2)}{R_1^2(R_2^2 - R_0^2)}P_0,$$

and the resisting power of the tube by the formula

$$P_1^{(1)} = \frac{R_1^2 - R_0^2}{2R_1^2}\theta_0.$$

In all cases $P_1 + p_1$ has been found to be less than $P_1^{(1)}$.

R_0 = Interior radius of tube.
R_1 = Exterior radius of tube and interior radius of jacket.
R_2 = " " of jacket.
$\rho_0 = \theta_0$ = Elastic strength of metal of tube.
P_1 = Strength of tube alone.
P_0 = Strength of tube supported by jacket.
E = Modulus of elasticity = 29,000,000.
φ = Shrinkage per linear unit.

S_1 = Total shrinkage on diameter.
D_1 = Interior diameter of jacket.
θ_1 = Elastic strength of metal of jacket.

These formulæ, while not making so good a showing for strength of gun, are still the most reliable to work upon in constructing built-up guns.

The factor of safety is about 50 per cent, so that the actual elastic strength of the Driggs-Schroeder 6-pounder is about 30 tons per square inch. The ultimate or tensile strength of this caliber is about 40 or 45 tons per square inch, depending on the quality of the steel used.

The tube and jacket are proportioned, as near as possible, so that the exterior radius of tube will be a mean proportional between the interior of tube and exterior of jacket. This cannot always be done, but the nearer the approach to this proportion the stronger the construction. In all the Driggs-Schroeder guns this point is very nearly reached, and therefore the design is, theoretically, as near correct as it can be made.

BREECH-HOUSING.

The breech-housing being closed at the top excludes dirt and rain, while it is a great support to the rear end of the chamber.

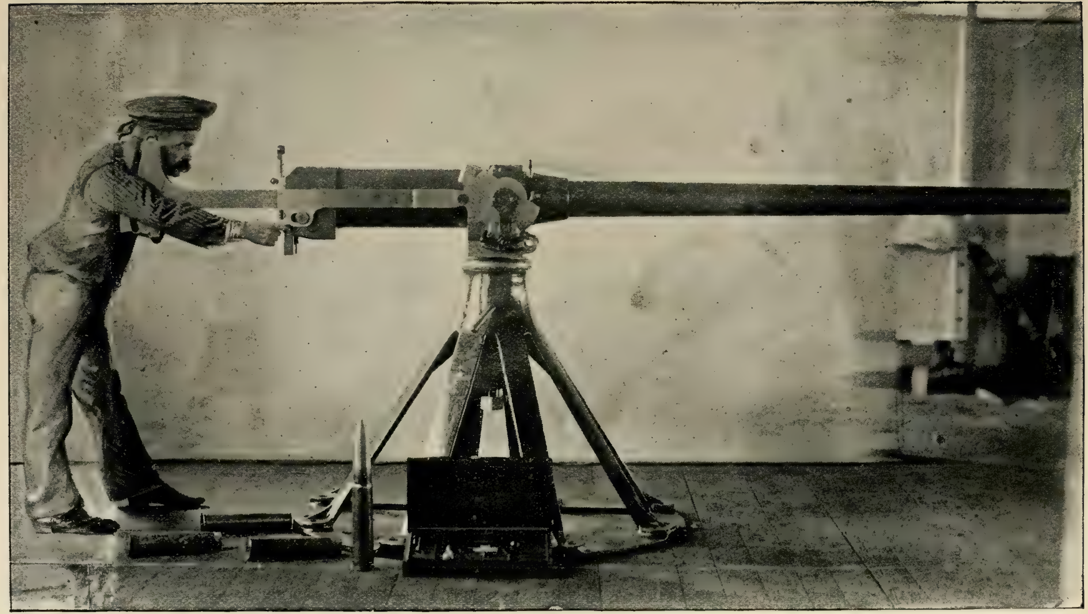
It has long been known that guns on the sliding-wedge principle were faulty in construction, because the breech-block, being held to the body of the gun simply by two side-pieces, the repeated strains brought these sides closer together and changed the shape of the chamber from round to oval.

GREATER RANGE, ACCURACY AND PENETRATION FOR THE SAME WEIGHT OF GUN.

The rapid-fire 3- and 6-pounders which were first put in service in this country had a length of bore of 40 calibers. Much of the weight of the gun was taken up in the weight of the breech mechanism and its housing.

When the Driggs-Schroeder was designed, a large amount of weight was saved at the breech, so that it would have been possible to make a 40-caliber gun on this design weighing some 50 pounds less than those in service at that time, but it was thought better to use the metal saved at the breech towards strengthening the chase and lengthening the bore. This was done, the bore being lengthened five calibers.

4-INCH GUN LATELY COMPLETED AT WASHINGTON YARD.



6-POUNDER.

This increase has put from 40 to 70 f. s. on the muzzle velocity of the shell, depending, of course, on the loading. On this point, the report made on the first 3-pounder tested at Annapolis, which was about 44 calibers length of bore, was as follows:

"Theoretically, the increase of velocity due to four calibers increase length of bore is about 70 f. s. The results of practice show that the theoretical conditions are fulfilled.

The following velocities were obtained:

Charge, 763 grams N. D.

Projectile, Hotchkiss common shell, 1500 grams.

I. V.	2042	f. s.
	2052	"
	2042	"
	2057	"
	2046	"
Mean	2048	"

PRESSURES.

The tests made on this point show that there is no difference between the pressures in this and in the Hotchkiss guns of the same caliber, the powder and projectile being the same."

The advantages therefore claimed for the Driggs-Schroeder guns (distinct from those claimed for the breech mechanism, mentioned later) are:

1. For same weight and strength of gun, greater range, accuracy and penetration.
2. A natural housing for breech mechanism.
3. More reliable construction.

2. BREECH MECHANISM.

The essentials of a good breech mechanism for any system of rapid-fire guns are:

1. Safety.
2. Ease and rapidity of working breech mechanism.
3. Certainty and force of extraction.
4. Protection of mechanism.
5. Complete ejection of the empty case.

SAFETY.

As regards this essential, the strength of the breech-block and its support, in the Driggs-Schroeder gun, is sufficient in the 3-pounder to sustain a chamber pressure of 60 tons per square inch, and in the 6-pounder 70, without in either case passing the elastic strength of the metal. The usual working pressure is only 15 tons per square inch. For further proof of the safety of the mechanism we quote from official reports on 3-pounder:

"The maximum pressure developed in the bore has been 18 tons. Under this and the frequent repetition of lower pressures (about 12 to 15 tons) the block has shown no signs of weakness.

If fully closed before firing, it is, I think, amply strong both in itself and in its support.

Experiments were made to determine whether the cap could be snapped and the gun fired before the breech was fully closed.

There was found to be no possibility of such an accident, the arm of the cocking cam being always interposed to prevent the firing pin from striking the cap until the breech is locked.

It is a feature of this system which gives it an advantage over certain others that the firing pin may be set and kept at half-cock. Tested in this position, it is found to be free from danger of accident.

It may be said, therefore, that the safety of the system is at all points satisfactory."

Report on 6-pounder is as follows:

SAFETY.

"The new locking device answers its purpose well. No liability of its being jarred or knocked open while firing was noticed. It was found there was no possibility of firing before the breech was closed and locked.

The strength and endurance of all parts appear to be sufficient."

EASE AND RAPIDITY OF WORKING BREECH MECHANISM.

The lightness combined with a revolving motion of the breech-block results in increase of rapidity of firing and decrease of fatigue in working. This is further augmented by the fact that the cartridge need not be accurately placed. If the case is within three-fourths of an inch of being home, the motion of the breech-block will complete

the loading as well as if the rim of the case was close against the extractors.

The breech-block of the 6-pounder Driggs-Schroeder gun weighs 26 lbs.; the corresponding part of the other 6-pounders in service weighs 59 lbs. The difference in the 1 and 3-pounders shows the same proportion of decrease.

This saving of weight is an important factor in rapid firing, especially if the maximum rate of fire is continued any length of time. Without doubt there is a great difference between the rate of fire of aimed and unaimed shots, and also the rate at which ammunition can be supplied will limit in a degree the rate of fire. This fact is brought forward by some ordnance men to sustain an assertion that there is no advantage in increase of rapidity of operating the breech mechanism. The supply of ammunition is not changed by changing the breech system; neither is the time occupied in pointing. The only operations, therefore, that vary with the change from one system to another is the loading and extracting. It is obvious, therefore, that the less time is occupied in these operations the less time there will be between the different shots, and this will be the case whether the gun is aimed or unaimed.

Ammunition is supplied in boxes containing from 11 to 40 rounds, so that the supply of ammunition would not change the rate of firing a volley, though it might change the time between the volleys.

It is plain, therefore, that the gun that can fire the greatest number of unaimed rounds can also fire the greatest number of aimed rounds, allowing the same time to each for pointing.

No test has ever been made in this country to determine the rate of aimed fire for any rapid-fire gun, so that no data on this point is at hand. The rate made with the Driggs-Schroeder 3-pounder, with an untrained crew, was 33 rounds per minute. This speed was attained on an official trial in England. The rate actually made in this country with the 6-pounder gun was 25 shots per minute, which was also accomplished with an untrained crew. This same crew (consisting of but 3 men) fired 61 rounds in 3 m. 36 sec. The official report on this part of the test is as follows:

"The rapid-fire test of 60 rounds, fired as rapidly as possible, was commenced at 11.05. The start was made with the breech open, and a cartridge in the hands of No. 3.

The times were made as follows:

1st	10 rounds in		27	seconds.	
2d	10	" "	30	"	
3d	10	" "	35½	"	
4th	10	" "	44½	"	including 1 misfire.
5th	10	" "	34½	"	
6th	10	" "	44½	"	
		Total, 3 m. 36s.			

The last round was fired at 11.08.36.

The test virtually occupied the time of 61 rounds, or on an average of 3.54 seconds to a round. When the misfire occurred, the time from fire to fire was 12 seconds.

At the end of this test the face of the breech-block was cool to the hand. The temperature of cylinder over chamber 92°. At the muzzle the temperature rose to 175° in 1 min., and continuing to rise, reached the limit of the thermometer, 212° in 1½ min., the mercury boiling and solder melting."

For a practiced crew the reports are as follows:

"With a well-exercised crew the gun could, I think, be fired at the rate of 30 rounds a minute, for one minute or less."

CERTAINTY AND FORCE OF EXTRACTION.

In the Driggs-Schroeder there are two independent extractors, either of which will extract the case. Besides this advantage, two extractors are better than one, for the reason that, being placed so as to press on the rim at opposite ends of a diameter, the case is not cramped by being pressed over to one side; also, if the rim is a little weak it is more likely to hold, as the strain is divided between the two points of contact with the extractors.

Since the trial of the first experimental Driggs-Schroeder 3-pounder at Annapolis in February, 1888, there has not been a failure of a single extractor, though the guns have fired over 1000 rounds.

All of the Driggs-Schroeder guns, both large and small, are designed to eject the empty case well clear of the gun after firing, and this seems to us indispensable for a rapid-fire gun. Where the empty case has to be handled and withdrawn from the gun by hand, time is lost, and unless great care is taken, the man whose duty it is to handle the empty case is liable to burn his hands, as they often come out very hot. During one of the trials of a 6-pounder the empty cases collected about the rear of the gun, and one coming in contact with

the shoe of the captain of the piece, burnt the leather. With this experience it seems advisable to handle empty cases fresh from the gun as little as possible. If large-caliber guns cannot be designed to entirely eject the case and it is necessary to handle them, heavy gloves covered with some non-conducting substance might be used to protect the hands, but when there are large rapid-fire guns that work well it seems unnecessary to go to the trouble of getting special gloves and losing time to handle hot empty cases.

PROTECTION OF THE MECHANISM.

The housing for the breech mechanism is only open at the bottom and rear, so that the mechanism is entirely protected from shot or falling fragments; the only pieces exposed are the pistol-handle on one side and the operating-handle on the other. Even were the pistol-handle shot away the gun could still be worked, and almost as efficiently as with it. In designs having the housing for the mechanism open at the top, falling fragments are apt to lodge there, rain beats in, and on shore sand and dust will collect in the mechanism. Besides this, a breech-block supported only at the back requires much more metal in the housing than should be put in this part of the gun.

In almost every system using a sliding or vertically moving block this part of the mechanism projects beyond the housing both at top and bottom, so that even when the gun is closed the breech-block, which is the keynote of the whole mechanism, is at all times exposed to accidental blows or injury in action.

The use of the screw-plug for rapid-fire guns is even worse.

In all the systems devised to utilize this mode of closure, almost the entire mechanism is exterior to the gun. To perform the many motions necessary for the plug to go through requires a complicated system of cogs and levers. The plug must be revolved, withdrawn and swung around on a tray; all with one motion of the handle. On the tray the plug is only held in place by the friction due to its own weight on a movable knuckle. The whole mechanism must be entered and withdrawn at every fire. A slight displacing of the breech-block in the tray (which is an easy matter) will prevent the plug being returned to the gun.

During all the operations of loading the whole mechanism is out of the gun and at the side, exposed to accidents of all kinds.

Peculiar as it is, it is still a fact that many officers think that any

system using the interrupted screw-plug is good because it utilizes that closure, and yet this same interrupted screw-plug has a longer record of accidents, injuries and deaths than all the others put together. Very few professional men who read this paper but who can recall some serious accident from the use of the screw-plug breech-closure. They invariably have an explanation of the cause, but that is little satisfaction to the victim or to his friends.

The advantages, therefore, of the Driggs-Schroeder system over others may be condensed as follows:

1. No danger can result from a hang-fire or misfire.

2. The gun can be left loaded and half-cocked and can be cocked again without opening breech.

3. The mechanism is thoroughly protected from small shot and accidental blows.

4. The breech-block is 50 per cent lighter than some other systems, and lighter than any known, from which results:

5. Greater length of gun for same weight. This results in:

6. Greater velocity and therefore greater muzzle energy.

7. (4) also results in a greater rapidity of fire over other systems of from 5 to 10 shots per minute.

8. Since the block revolves, the full weight of the block is only felt for an instant.

In long-continued firing this would be of the greatest importance to the operator.

9. From (4) it is evident that the system can be carried to heavy guns.

The block of the Driggs-Schroeder 36-pounder only weighs 68 pounds, the full weight of which is only felt for a drop of one inch.

10. The shoulder-piece is on the right side, which is the natural position to fire.

11. Three men only are required for a crew.

12. The handle being on the left side, the loading and operating is done on the left side of the gun. This leaves the captain of the gun (who is on the right side with his right shoulder against the shoulder-piece, and the right forefinger on trigger) with a clear field of vision, so that pointing and loading go on together.

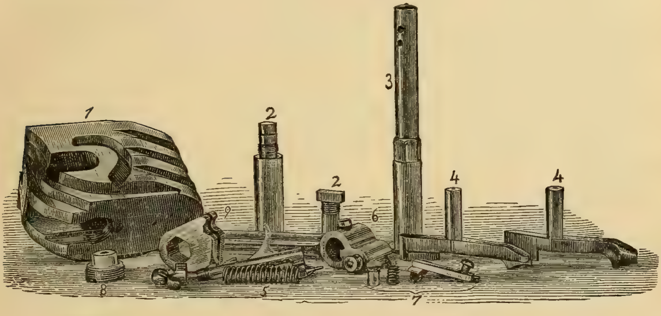
13. The cases need only be pushed to within one inch of extractors.

Regarding the handling and pointing of the piece we quote from the official report upon the Driggs-Schroeder guns, tested at Annapolis, as follows:

"The shoulder-piece of the gun is on the right-hand side and the handle on the left. There result from this arrangement, taken with the lightness of the block, certain marked advantages.

The man who works the handle is on the left of the gun. He can work the handle perfectly with the left hand, which leaves his right hand free for loading and inserting the cartridges.

We found in actual firing not only that this arrangement, which does away with one man and reduces the crew of the gun to three, is practical, but that it is much better than to have four men. As the same man inserts the cartridge and closes the breech, there can be no danger of jamming the cartridge or the hand by starting up the block too soon."



1. Breech-Block.—2. Guide Bolts.—3. Main Bolt.—4. Extractors.—5. Firing-Pin and Spring.—6. Operating-Handle.—7. Sear-Bolt Spring and Cap for Holding Spring in Place.—8. Screws for Holding Face-Plate in Place.—9. Operating-Cam.

DESCRIPTION OF THE BREECH MECHANISM.

Referring to the drawings, Fig. 1 represents a longitudinal section of the breech end of the gun and the breech-block, the cam and firing-pin being shown in side elevation, and other parts and features in dotted lines. Fig. 2 shows the same with the breech-block moved back into position for opening the chamber for the introduction of a cartridge. Fig. 3 is a rear elevation of the breech of the gun, with the breech-block closing the chamber, and a number of other parts and features shown in full and dotted lines. Fig. 4 shows a detail side view of the breech-block. Fig. 5 shows a front view of the same. Fig. 6 is a rear view of the cam in detail. Figs. 7 and 8 are respectively side and rear views in detail of the extractor-arm for the

right side of the breech-block. Fig. 9 is a detail side or edge view of the sliding leaf for holding and releasing the firing-pin. Figs. 10 and 11 are broken horizontal sections of the breech-block and sliding leaf, said sections being respectively taken on the dotted lines $x\ x$ and $y\ y$, Fig. 3. Fig. 12 is a vertical section of a part of the breech-block on the dotted line $z\ z$ of Fig. 1, showing the form of the cavity at that point. Fig. 13 is a broken side view of the breech and the operating handle, showing the spring-catch in the latter and the recess therefor in the former.

In the drawings, A represents the breech-block, which is provided on its upper surface with bands $a\ a$, which fit into correspondingly shaped grooves or recesses $a'\ a'$ in the upper interior surface of the breech A', and extend downward a suitable distance within the walls of the breech A^2. These bands and their grooves firmly hold the breech-block in position and prevent backward movement of the same during firing.

The breech-block A is formed with a cavity, A^3, extending from the front toward the rear, the general contour being represented in longitudinal and transverse section in Figs. 1 and 12. Formed in the front part of the cavity is a curved wall, 1 2, of suitable length, which merges into an upwardly inclined wall, 2 3, and in the rear upper part of the rectangular portion of said cavity is a round pin, 4, immovably secured therein.

The central front face of the breech-block containing the cavity is covered by a strong face-plate, 5, which is held in place by a locking plug, 6, screwed into the same and the cheeks of the cavity.

In the sides of the breech-block are formed cams or guide-grooves 7 7, which are of the shape shown in dotted lines in Fig. 1 and full lines in Fig. 4, their lower or rear walls from 8 to 9 being nearly vertical, but slightly inclined forwardly. From the point 9 said guide-grooves continue on in curved lines from point 10 to point 11, the two latter points of said grooves being concentric with the axial bolt when in the upper part of the elongated opening in the breech-block, the purposes and functions of these parts and features being hereinafter fully described. Projecting into the guide-grooves 7 7 are guide-studs 12 12, which are secured in the walls of the breech. The elongated opening 13 is also formed in the breech-block—in its lower portion—and is inclined forward two or three degrees from the vertical, so as to allow of a movement of said block when closing. A strong axial bolt B passes through said elongated opening, fits in openings in the walls or

PLATE I.

Fig 1.

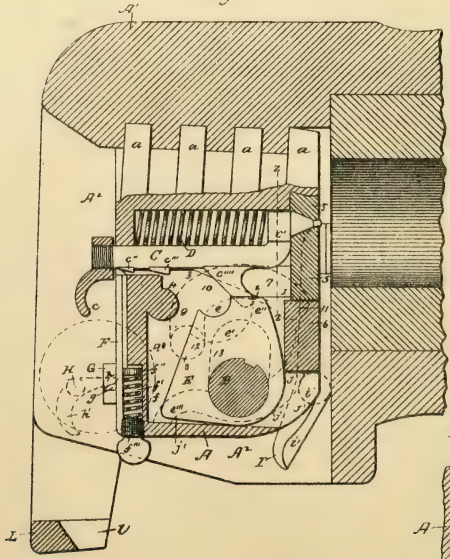


Fig. 2

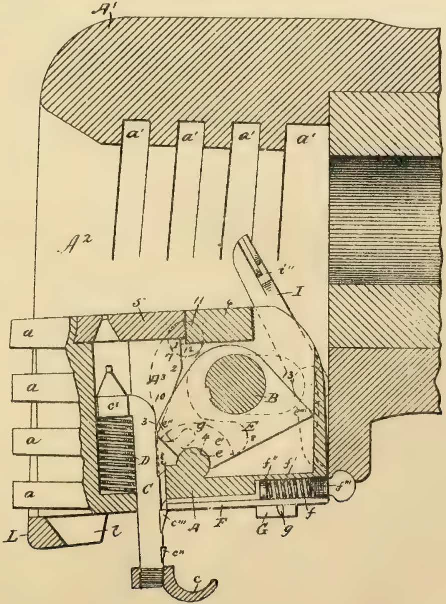


Fig. 12.

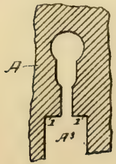


PLATE II.

Fig. 3.

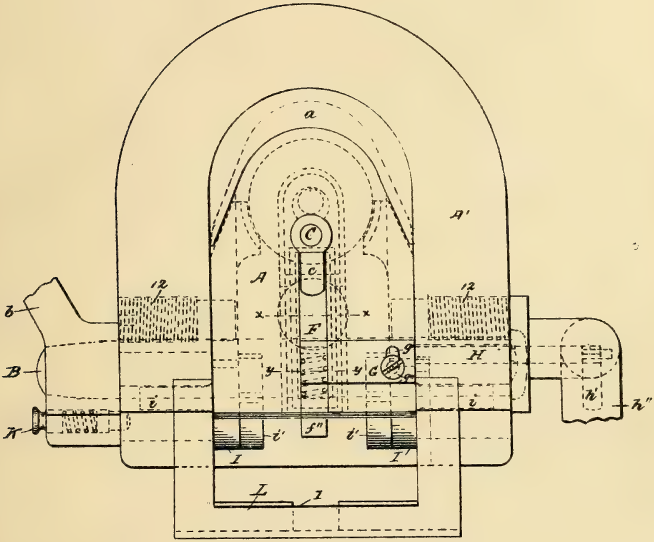


Fig. 4.

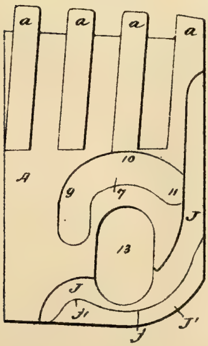


PLATE III.

Fig. 5.

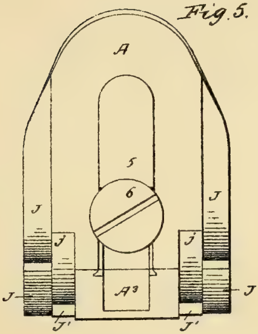


Fig. 6.

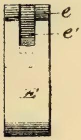


Fig. 9.

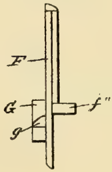


Fig. 7.

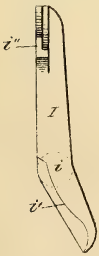


Fig. 13.

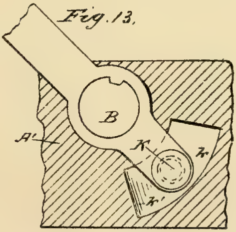


Fig. 8.

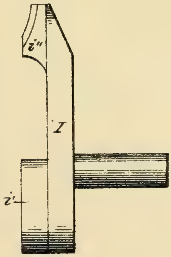
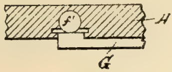


Fig. 10.

Fig. 11.



cheeks of the breech, and extends out beyond the same on the left side, where it is provided with an operating handle, b.

In the upper part of the cavity in the breech-block, or above the rectangularly shaped part of said cavity, is arranged the firing-pin C, which is provided at its rear end with a finger-loop c, and at its front end with an upturned head, c'. On the under side of this firing-pin, toward its rear end, are respectively formed half and full cock-studs, c'' and c''', and a downwardly and forwardly extending cocking-lug c'''' is arranged near its middle. In the top portion of the cavity, above the firing-pin, is arranged a spiral spring, D.

In the left upper end of the cam E, and extending its full width, is formed a circular recess, e, which is struck with the same radius as the rounded pin 4 in the cavity of the block. Beneath said recess e and in the middle of the upper rear part of the cam, is formed a larger curved and walled recess e', as shown in dotted lines in Fig. 1 and in rear view in Fig. 6, which terminates in front at the point e'' of the cam. This point, when the breech-block is closed, rests beneath the curved wall 1 2 of the cavity and supports said block in raised position. At the rear lower end of the cam is a toe, e''', which, when said cam is turned backward, exerts a downward pressure upon the lower wall of the cavity in the breech-block and cams the block down.

In the rear of the breech-block is located the sliding leaf F, which holds and releases the firing-pin, and which fits in a mortise cut in the rear face of the block and extends downward from the hole for the firing-pin. Side views of this sliding leaf are shown in Figs. 1 and 9, and transverse sections of the same and its mortise in Figs. 10 and 11, which are respectively views on the dotted lines x x and y y of Fig. 3. A coiled spring f is located in a vertical cylindrical recess, f', in the rear wall of the breech-block and presses the sliding leaf up against the firing-pin. The top of this spring bears against a flat circular lug f'' on the front side of the leaf. The spring is introduced at the bottom of said recess and held in place by a plug f'''. From the rear face of the leaf projects a laterally extending arm, G, which terminates in a lip g having a rounded rear face as shown in Figs. 1 and 9. A vertical slot g' is formed in said arm, and a screw-stud g'' passes through the same and into the block, whereby the vertically sliding leaf is kept in proper alignment.

A small rock-shaft, H, passes transversely through the right wall of the gun-breech, and its inner end terminates in a recess in said

wall in rear of but out of line with the side of the breech-block. On the inner end of said rock-shaft is a trip or finger, *h*, which is normally just in contact with the rounded lip *g* of the laterally-extending arm *G* of the sliding leaf *F*, while on the outer end of said rock-shaft is secured a finger-piece or trigger, *h'*, which projects downward beneath the usual hand-rest or pistol-grip, *h''*, and which, on being pressed by the finger, causes the trip *h* to bear down upon the lip *g* of arm *G*, and thus slide the leaf *F* downwardly against the resistance of the coiled spring *f* and liberate the firing-pin *C*, which then flies forward against the primer and explodes the cartridge.

The cartridge-case extractor consists of two upwardly-extending arms, *I I*, provided with lateral pins or pivots *i i*, which project into openings in the inner surfaces of the walls of the breech. As the breech-block *A* is flush with or takes up the whole width of the breech-chamber, the sides of said block, along its bottom and front surfaces, have formed therein recesses *J J*, which are of a depth inward from the sides of said block, equal to the width of the long or main portions of the extractor-arms *I I*, sufficient room being provided at the upper ends of said recesses to permit the block to descend slightly along the extractor-arms previous to the commencement of its rotary movement. On the inner sides of the extractor-arms, along their lower rearwardly-projecting ends, are formed curved projections *i' i''*, which extend into recesses or steps *J' J'*, formed along the lower front and bottom parts of the breech-block, and which are still deeper or cut farther in from the sides of said block than the recesses *J J*. These deeper recesses or steps, when the breech-block descends to its revolving position, will bring their upper curved walls, *j j*, in contact with the curved projections *i' i'* on the inner sides of the extractor-arms. These upper walls, *j j*, of the deeper recesses or steps *J' J'* are circular in form for a certain distance, as shown in Fig. 4, and are slightly eccentric with respect to the center of rotation of the block, so that during its rotation, as hereinafter described, said walls will press slightly and slowly against the curved projections *i' i'* on the inner sides of the lower ends of the extractor-arms, and thus cause the heads *i'' i''* of said arms (said heads being suitably fashioned to grasp the rim of cartridge-case) to move slowly to the rear and pull the shell along with them. At the rear ends, *j' j'*, of the deeper recesses or steps *J' J'* the upper walls, *j j*, change in curve abruptly downward; hence these abrupt curves, coming in contact with the curved projections on the extractor-

arms, when the block has rotated sufficiently to the rear to fully expose the bore of the gun, will cause the extractor-heads i'' i'' to suddenly pull or jerk the cartridge-case and throw the same quickly to the rear.

Secured within the interior surfaces of the breech-walls, and suspended therefrom at the extreme rear of the breech, is a strong tray or support, L, which receives and sustains the weight of the breech-block when it is turned back and the bore is open for loading. As the cam E rotates rearward and the block A descends, the cocking-lug c'''' of the firing-pin C takes against the bottom of the curved walled recess e', formed in the middle of the upper rear part of said cam, and is moved rearward, the portion of the cam in front of said recess passing up into the curved front part of said cocking-lug. This pushing or retracting movement imparted to the firing-pin is effected against the resistance of the spiral spring D, which is contracted thereby, and said movement is continued until the circular recess e in the cam embraces the round shoulder 4 in the cavity, when the relative motions of the cam and firing-pin cease. When the recess e of the cam comes in contact with the round shoulder 4, the full-cock stud c''' of the firing-pin has passed the rear of the block and is caught by the sliding leaf F, before described.

Fig. 1 represents the breech of the gun as closed, or as it would appear after a discharge. To open the bore, the handle b is pulled to the rear, which turns the axial bolt B and the cam E. When the latter has been turned back a sufficient distance to cause its front point e'' to pass out from beneath the wall 1 2 of the cavity in the breech-block, the toe e''' of said cam will press down upon the bottom wall of the cavity and force said block downward, this movement being permitted by the point e'' of the cam moving along the inclined wall 2 3 of the cavity. After further turning the cam, accompanied by the downward movement of the block, its circular recess e embraces the rounded pin 4 in the cavity, and after this the further rotation of the cam is necessarily accompanied by the rotation of the block, which by this time has descended far enough for its axial bolt B to move to the upper part of the elongated opening 13, and for the bands to clear their grooves in the breech. After this, the movement of the block is rotary and to the rear around the axial bolt, it being guided by the cam-grooves 7 7 in its sides, and the guide-pins 12 12. To close the gun, the handle b is turned forwards. At first the rounded shoulder 4 remains engaged in the circular

recess *e* of the cam and causes the block to swing upward. In the meantime the guide-grooves in the sides of the block move over the pins or studs. On reaching point 10, in consequence of the change of the curves of the grooves, the upper surfaces or walls of said grooves take against the pins and are moved upward, thus forcing upward the breech-block and disengaging the rounded pin from the circular recess *e* of the cam. When this is effected, the front point e'' of the cam commences to impinge at the point 3 in the cavity, and the rotary motion of the cam continuing, moves along beneath the inclined wall 2 3 in said cavity and forces the breech-block upward. In the meantime the guide-pins change position in the grooves, moving from points 9 to points 8; also, the axial bolt changes position from the top to the bottom of the elongated opening 13. When the point e'' of the cam reaches the lower or front end of the inclined wall 2 3, it moves a short distance beyond the same and beneath the wall 1 2 in the cavity and firmly supports the breech-block in its raised and closed position. Further forward motion of the cam is prevented by coming against the face-plate 5, and by th catch on the handle.

TABLE OF GENERAL DIMENSIONS AND WEIGHTS OF DRIGGS-SCHROEDER GUNS.

	1-pdr.	3-pdr.	6-pdr.
Caliber, inches	1.457	1.85	2.244
Length of bore, inches	58.28	81.45	100.98
Length of bore, caliber	40	44	45
Length of rifling, inches	51.9	65.75	98.3
Length of gun, "	61.08	87.26	107.98
Number of grooves	12	20	24
Depth of grooves, inches	0.015	0.0158	0.015
Width of lands, "	0.0594	0.0787	0.0737
Weight of gun complete, lbs.	100	497	800
Weight of breech-block, "	5	16	26
Weight of powder, ounces	4.6	27.53	31.5
Weight of projectile, pounds	1.1	3.3	6
Muzzle velocity of projectile, f.s.	1800	2100	1880
Number of fires per minute	40	33	30

Twist of rifling, 1-pounder—1 turn in 30 calibers.
" " 3-pounder—1 turn in 100 to 1 in 25 calibers.
" " 6-pounder—1 turn in 150 to 1 in 27 calibers.

In the 3- and 6-pounder the twist of rifling is that of a semi-cubical parabola. Theoretically, this curve produces less strain on the rotating band than any other, and less than a uniform curve.

SIGHTS.

The sighting of the guns is such as to admit of either quick rough sighting or very close fine sighting.

The sights, both front and rear, have rings one inch interior diameter each, through which the line of sight passes.

In the front ring there are single cross-wires, and in the rear sight-ring double cross-wires. For rough sighting it is sufficiently near to keep the rings concentric and the target in the center without regard to the wires. At the distance the front sight is from the rear one the front ring appears considerably smaller than the other (about one-quarter inch diameter) so that the eye will catch the position of center with a very small error. The advantage of the rings is that they give a clear view all around the target, and the motion of the platform and of the target can be anticipated and the sights kept on with little difficulty. With the sight-notch in a solid bar the target is only visible when it is above the line of sights, and motion of the ship or target cannot be anticipated.

When no other drill is provided the following is used:

DRILL OF THE 1-POUNDER, 3-POUNDER, AND 6-POUNDER DRIGGS-SCHROEDER GUNS. (CREW OF 3 MEN.)

Nos.	Stations.	Arms, Revolvers.
1	1st Captain	1
2	2d Captain	1
3	Shellman	1

(*Note.*—The crews of the secondary battery are not assigned as boarders or riflemen.)

The exercise supposes the guns to be mounted in place and lashed, as well as clamped against elevation and train.

WORDS OF COMMAND.

I. Silence! Cast loose and provide!
II. Load!
III. Point!
IV. Commence firing!
V. Cease firing!

VI. Unload.

VII. Secure.

A gun's crew consists of three men, all of whom should be, as far as practicable, thoroughly trained rifle-shots.

The stations of the crew for mustering, when the gun is secured, are as follows: For guns mounted on deck—in line, directly in rear of the gun, facing inboard, No. 1 on the right; for guns mounted aloft—on deck, abreast the mast, facing outboard, No. 1 on the right.

I.—*Silence.*

This is preparatory, and is given to secure attention to the following order:

CAST LOOSE AND PROVIDE.

1 commands; removes gun cover; casts adrift gun lashings; places sight cover clear; ships gun stock; tests breech mechanism; examines bore; sees in place gear and implements for the service of the gun; for drill, puts on drill washers.* When all is ready, reports to officer in charge and takes station in rear of and facing gun.

If gun is mounted aloft, he first goes aloft and sends down tackle for hoisting up ammunition and other articles for the service of the gun; receives articles whipped up by 2 and 3.

2 provides and examines the reserve box containing the accessories and spare parts;† provides three revolvers and belts, and puts revolvers in rack near the gun; provides clean swab; adjusts drill apron;‡ sees trunnion and pivot clamps in working order; sees carriage in working order; takes his station at left side of breech and facing it. If the gun is mounted aloft, he does not go aloft until all the articles for the service of the gun have been whipped up; then secures net to top under lubber's hole.

3 provides swab and bucket of water; brings ammunition from hatchway§ and places it in rear of gun amidships; takes station alongside the ammunition. If gun is mounted aloft, assists 2.

After performing his duties, every one will put on his belt with revolver. After inspection by the division officer, and at his order "*Lay aside belts and arms*," the belts and revolver will be removed and placed clear of the gun.

II.—*Load.*

1 places right shoulder to stock; seizes the directing handle with left hand, and as soon as gun is unclamped, lays it with muzzle outboard; plants feet firmly to resist motion of the ship.

* See note 12. † See note 14. ‡ See note 13. § See note 2.

2 assists 1; unclamps pivot and trunnion clamps as soon as 1 has his shoulder to the stock; grasps with left hand and throws back smartly breech-block lever, opening breech;* takes cartridge from 3, points the shell fairly, and then enters it smartly in the gun and closes breech.† Performs duties of 3 while the latter is providing fresh box of ammunition.

3 passes cartridges to 2.

III.—*Point.*

1 steadies the gun with the right arm and shoulder; adjusts sight, seizes pistol-grip, finger on trigger, and with his eye ranging over the sights, steadies the piece upon the object.

2 attends trunnion and pivot clamps. At a sliding pivot mount, adjust the position of pivot for train.

IV.—*Commence Firing.*

1 tends sight, rectifies aim and fires;‡ after reloading again rectifies aim and fires, and so on.

2 tends clamps and loads.§

3 supplies ammunition to 2, and in rapid firing stands by to relieve him; keeps empty cases clear of gun; when ammunition is nearly exhausted, provides a fresh supply.||

V.—*Cease Firing.*

1 removes his hand from pistol-grip, and steadies the gun until the pivot and trunnion clamps are tightened.

2 tightens trunnion and pivot clamps; half-cocks.

VI.—*Unload.*

2 grasps breech-block lever and draws it back *easily* with left hand, keeping right hand in rear of breech opening; removes cartridge;¶ passes it to 3; sponges bore if necessary; closes breech.

1 eases firing-pin forward when breech is closed, then, assisted by 2, cleans and oils mechanism, if necessary.

3 receives cartridge from 2, replaces it in box,** then closes box.

* See notes 4, 6 and 7. † See notes 3 and 5. ‡ See notes 8 and 9.
§ See notes 3, 4, 5, 6, 7 and 8. || See note 2. ¶ See note 6.
** See note 10.

VII.—*Secure.*

The numbers return what they provided, and secure what they cast loose, the gun having first been laid to the securing position.*

DIRECTIONS FOR DISMOUNTING AND ASSEMBLING THE MECHANISM.

1-pounder, 3-pounder, 6-pounder Driggs-Schroeder on non-recoil stand.

No. 2 clamps the gun.

3 backs out right guide-bolt; 1 raises rear end of stock; 3 re-enters guide-bolt (not far enough to engage in guide-groove); 1 lets stock down to rest on it. (If it is desired to take stock off entirely, 3 removes its pivot-bolt on the Y and takes it off.)

The breech being closed, 2 backs out left guide-bolt; takes off operating handle; taps end of axial-bolt to start it; 1 holds block from underneath with left hand, and with right hand holds on to finger-catch of firing-pin; 3 draws out main bolt, assists 1 to lower block out of place.† The block being out, 1 full-cocks; 3 removes face-plate; 1 uncocks by bearing down on sear arm, and then takes off finger-catch on rear end firing-pin;‡ 3 takes out firing-pin and spring; 1 takes out sear-plug, sear-spring and sear; 2 takes off sight, takes out extractors, removes pistol-grip, trigger, rock-shaft and tray.

Except in rare instances, such as dismounting for transportation or cleaning the sights, pistol-handle and tray should not be removed.

To Mount.

Proceed in the reverse way to dismounting; firing-pin must be full-cocked before putting in face-plate, and let down to half-cock after face-plate is in place.

DETAIL NOTES UPON THE EXERCISE OF DRIGGS-SCHROEDER GUNS.

1. To secure to the crew the freedom of movement necessary to the efficient serving of the gun, arms and equipment should not be carried until required for use.

2. The number of rounds of ammunition to be brought to each gun as a first supply will be regulated by the commanding officer, and will depend upon the requirements at the time. In the absence of orders, a full box will be supplied.

* See note 11. † See note 16. ‡ See note 15.

During action the ammunition supply for R. F. guns is dependent mostly upon the rapidity with which it can be whipped up from below. It would be impossible to supply it as fast as it could be used in continuous rapid-firing. It will therefore be necessary to take advantage of all interruptions of fire to increase the supply at the gun, with a given whipping capacity; the carrying from the hatches to the guns depends upon the distance and accessibility. One man, named conveniently Supply-man, assisted by No. 3 of each gun, can probably supply ammunition to four guns (two on a side) as fast as it is received from below. There may, therefore, be a Supply-man detailed for every four guns of the secondary battery. With Driggs-Schroeder guns, Nos. 1 and 2 can fire 12 to 15 shots a minute with No. 3 away.

3. In inserting the cartridge, 2 will keep it in mind to hold the rear end slightly raised with reference to the point, so as to avoid driving the point of the shell against the upper edge of the chamber. The lower edge and sides are protected respectively by the breech-block and the extractors.

Neglect to observe the above precaution may result in a burr about the upper edge of the chamber.

While it is not necessary that the case should be pushed home against the extractors, it will be safer to send it well home. The extractors have a certain amount of yielding that will accommodate itself to any severity of ramming within reasonable limits.

4. If, after firing, the cartridge-case sticks after partial extraction, fully extract and then look for dirt or caked powder in the chamber. If such exists it must be removed with sponge if there is time.

5. If, in loading, a cartridge jam and will not let the breech-block close, never attempt to drive it home by forcing the block; unload at once, put the cartridge aside and try another.

6. If the case does not extract, ram it out from the muzzle.

7. If one extractor breaks, the other will extract satisfactorily; but the first opportunity should be taken to put in a new one: back out the guide-bolts, half-cock, draw axial-bolt, holding the block by hand; lower the block far enough to expose the extractor, resting the upper part on the tray for support; pull out the broken extractor and put in the new one. Do not put in the new extractor with a cartridge already in the gun, as the rib will come on the wrong side of the cartridge-head.

8. If the primer misses fire, full-cock again without removing block; in so doing the tension of the main-spring will indicate

whether or not it is broken. If it feels stiff enough, but misses again, open and extract, put in new cartridge and try again. If it still misses, dismount the block, remove the face-plate and renew the firing-pin or spring, whichever is found defective. If the cap should have failed to obturate at any shot it is possible that a residuum may have been deposited on the front end of the firing-pin or rear face of face-plate, which might shorten the throw of the former and prevent it striking the cap.

9. In action do not try a second time any cartridge that has once failed unless it is absolutely necessary. To do so is an unnecessary experiment by which a telling shot may be missed.

10. In returning ammunition great care must be taken that empty cartridge-cases are not put in ammunition boxes containing loaded cartridges, and *vice versa*. 3 is held responsible for attention to this.

11. After ammunition boxes have been sent below, and before stowing them in the fixed ammunition rooms, the men stationed in the latter will redistribute the ammunition so as to completely fill all partially filled boxes but one. This last partially filled box should never be sent on deck in supplying.

12. The drill-washers are designed to prevent the firing-pin from delivering a sharp blow on the face-plate when snapping the gun at drill, and from delivering too strong a blow when drill cartridges are used. They should not be kept on when the piece is secured, as they increase slightly the compression of the spring when uncocked.

13. The drill apron is used only when the exercise is with drill cartridges.

14. Reserve boxes for 6-pounder, 3-pounder and 1-pounder contain the following accessories and spare parts:

Accessories—Sponge brushes, cleaning brush, oil can, screw-driver (special), clamping wrench, drill-washers.

Spare parts—Firing-pin, firing-springs, right and left extractors, sear, sear-springs, set of gun-screws.

15. In dismounting, the firing-pin must be uncocked before taking off the finger catch, otherwise the former would fly out with some force and possibly be lost.

16. In lowering the block, tip the upper end slightly to the rear as soon as the bands are disengaged, and, holding on to finger-catch, lower block (forward of tray) in the hands of No. 3.

17. Lard oil should not be used on any part of the mechanism, as it hardens in cold weather. Mineral or fish oil is best.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

REMARKS ON THE ORGANIZATION OF NAVAL ENGINEER FORCES.

By George Quick, Fleet Engineer, Royal Navy, Retired.
(Member U. S. Naval Institute.)

I venture to submit the following remarks to the members of this Institute, because, when I first made some little acquaintance with the United States Navy, some thirty years ago, I considered it was, as regards its engineer officers, the best organized navy in the world. And now it appears to me that the paper by Lieutenant Fullam, U. S. N., on "The System of Training and Discipline required to Promote Efficiency, etc.," and the Prize Essay by Ensign Niblack, U. S. N., on "The Enlistment, Training and Organization of Crews for our New Ships," and the discussions thereon, published in these Proceedings, Nos. 55, 57 and 58, plainly show that the United States Navy contains officers who are quite as progressive and broad-minded as any men in the world; and that, therefore, the remarks in this paper will be freely and fairly discussed on their merits, and that all weak points will be fully and fairly shown up.

In these days of rapid development of machinery, we are all of us tempted to wish that a vast leap forward could be made at once, so that we may have our power produced without the use of coal and steam on board ship. For more than thirty years the hope has been indulged that the use of liquid fuel would enable us to avoid the horrors of coaling ship; but even to-day we seem to be far off from this step forward being taken. Those who have had to superintend the coaling of a man-of-war in a tropical climate, when the steam has been up and the coal has been old and dusty, can alone realize what an immense blessing liquid fuel would be to all on board if it could only be brought into constant use. But there are certain objections to its employment

on board vessels of war, which objections do not apply to its use on merchant steamers or fast mail boats, so that we must expect to see it employed successfully in the mercantile marine before it is used in vessels designed for fighting. It is true that those enterprising people, the Italians, are making strong efforts to introduce it into their war ships; but it is possible that an action at sea, in which high-explosive shells may be used, may very much alter their views on this subject.

But far better than liquid fuel would be the use of stored-up electricity for the propulsion and production of power for the use of war-ships. Could we bottle up in a volume of one cubic foot, and in a weight not exceeding 100 pounds, and at a cost not exceeding one dollar, sufficient electricity to develop one horse-power continuously for 1000 hours, we should have arrived at a state of almost ideal perfection as regards power for propulsion and power for working the various machines on board ships of war. Then we could dispense with coal bunkers, boilers, funnels, heat, smoke, dust, dirt and stench, and nearly all the other abominations connected with steam.

Personally, I should rejoice in such an improved state of things on board ships, for I have no love for things as they are. I have no reverence for things simply because they are old, although I have a very great dislike to any change that does not bring an improvement commensurate with the trouble and expense of effecting the change. But I am certainly not prejudiced in favor of coal and steam, although I have been connected with them all my life.

Now, although I do not venture to say that within the next thirty years some new inventions in chemistry and electricity may not render electric propulsion possible and profitable, yet, unfortunately, I cannot see any hope of its introduction in the immediate future.

At this moment we have as little to do with the distant future of thirty years hence as we have to do with the remote past of three hundred years ago. It is almost as great a folly to look too far ahead as it is to be always looking back upon the past. In some armies and in some navies it is the fashion to allow the past to dominate the present. With that fashion I am not in accord. It is simply childish to be governed by the iron rules of past practice. On the other hand it is presumptuous conceit and vanity to disregard the lessons of past experience.

Let us for one moment consider a large example of the result of slavish obedience to the rules of the past. Let us turn our eyes to the year 1866, and to the Austrian army under Marshal Benedict, enslaved by the rules and traditions of the past, and we shall see the frightful

fruit arising from the worship of the dead past—we see the field of Sadowa, the crushing of a mighty army and the humbling of the proud Austrian empire.

Let us look again to 1866. We see the Prussian army governed by the thoughts and reason of living men. Those men had learnt a living lesson from the experience of the past. They had learnt that things must progress—that there is no standing still. They had altered their arms, their drill and their tactics, under the guidance of the progressive Von Moltke, who would not be bound by the practice of his youth or by the traditions of his predecessors. And we look again upon the field of Sadowa, and we see the glorious success of the Prussian army which had learnt from the experience of the past, from the wars in Europe and from the great civil war in America. It had learnt to cast aside the leading-strings of its childhood and to think and to act as reason and circumstances required, and thus it crushed and conquered the army which was governed only by the rules and practice of a dead generation.

It is useless to multiply instances to show the value of progress in war matters. Those who are opposed to progress should prove their case by showing how and when nations have suffered by adopting improvements in arms, improvements in organization and improvements in tactics.

I venture on the foregoing remarks because it has been my fate to meet with so many people who object to all change and who express their preference "for the good old times" when there was neither steam nor engineers on board of men-of-war. But amongst American officers there is probably less of this desire for retrogression than amongst any other naval officers in the world. Nevertheless, the views I have held for many years are sufficiently novel, I believe, to require these introductory remarks, and it is my desire that these views may be fully and freely criticized.

I need not attempt to call your attention to the giant strides which have been made in the application of steam, hydraulic power, compressed air and electricity to the modern men-of-war since 1860. But the advance between 1860 and 1870 was not so great as that between 1870 and 1880, and that again was not so great as the advance between 1880 and 1890. What the advance will be between 1890 and 1900 I will not now attempt to predict, but of this we may be certain, that it will not be less than that made during the last decade.

But whilst enormous changes have been effected in the engineering

materiel of all navies, how very little change has been made in the engineering *personnel* to correspond with the change in the *materiel* and the altered conditions of naval warfare! And in this respect of engineer *personnel*, the progress of the United States Navy has not been in proportion to the development of the *materiel*. Yet for the past four years the steam department of the U. S. Navy has been presided over by the most energetic and most capable officer that has ever held the position of Engineer-in-Chief in any navy.

No one who has read the Annual Reports of the Chief of the Bureau of Steam Engineering can believe that the non-development of the engineer *personnel* is due to the absence of effort on his part. But, unfortunately, the dead past, old practice and ancient traditions still actuate all governments in dealing with their navies.

No naval war on a large scale has occurred to bring home to any government the importance of the engineer force on board ship. And yet scarcely a day passes that evidence is not forthcoming of the vital importance of the naval engineer, and that on him primarily rests the fighting efficiency of every navy.

As I retired from the British Navy upwards of four years ago, I do not think I can be considered guilty of boasting if I say that in my opinion the engineer department of the Royal Navy has been for some years as efficient as that of any other navy in the world. I may go still further, now, and say that at present it is more efficient than the engineer department of any other navy, because the English Admiralty has of late years very wisely increased the power of the engineer officers over the men and *materiel* of the ships actually afloat. Yet I do not hesitate to assert my complete conviction that the engineer branch of the British Navy is not even yet organized for efficiently discharging the duties which will be required of it in time of war.

Let me give one small example of those things which are occurring every day in all navies.

"On the 13th July last, during target practice on board H. M. S. Trafalgar, the locking bolt of the after turret was broken, and the turret was practically useless for three days, although the ship's artificers worked day and night at the repairs." Here we see one-half of the fighting power of a ship of 11,940 tons and 12,000 horse-power disabled for three days by the breaking of a single bolt. But if the breaking of a single locking bolt disables the half of the fighting power of a 12,000-ton ironclad, and the repairs of that defect require the labor of the whole of the ship's artificers for three days and nights, what may we

expect when a ship has been engaged for an hour with an enemy of equal fighting power? How many mechanics will be required to repair damages after one heavy shell has exploded inboard? This question is easy to ask, but not so easy to answer.

If two similar ships fight, and each receives similar injuries, so that they are compelled to separate for repairs, then if one of those ships carries, say, thirty mechanics whilst the other ship carries sixty mechanics, the latter ship ought to be repaired and in fighting condition first, and should most assuredly capture or destroy the ship carrying the smaller number of mechanics.

It may be argued that the number of mechanics cannot be increased without reducing the number of fighting men on board. That is the one great fallacy which has prevented the development of the fighting power of all navies. Skilled mechanics are of all men the most easily drilled to become good fighting men with rifles, heavy guns, torpedoes or pistols. And the drill necessary to make them effective combatants also improves them as mechanics. (See Appendixes A, B, C, D.)

But the question may be asked, How are these combatant mechanics to be employed on board ship during peace? My answer is: They would mount guard and do deck duty in lieu of the marines. There are in all armies corps of combatant or military engineers, and in all navies there should be corps of combatant naval engineers.

It takes some years to make a man an efficient sailor, and it takes some years for a boy to become an ordinary skilled mechanic. But the great civil war of 1861-5, and numerous other wars, have clearly proved that good soldiers can be speedily made out of intelligent men. The recent reduction of the period of training of the German soldiers proves how much can be done in these days in making soldiers out of fairly intelligent men.

There is plenty of enterprise, daring and love of adventure amongst the young mechanics of England and the United States, but they have a sentimental objection to enter the navy under the name, style or title of "coal-heaver" or "stoker 2d class," especially as there is no prospect of rising from those ratings to those of machinist, artificer, or warrant officer.

It has, therefore, been my desire for many years past that the whole of the naval engineer branch, from the engineer-in-chief to the newly entered coal-heaver, should be formed into one body to be called "The Corps of Naval Engineers." (See Appendix C, pages 50–52.)

It is not to be expected that good mechanics could be got imme-

diately to enter the navy in sufficient numbers to do duty as coal-heavers, and therefore the ratings of the engine-room men would have to be something as follows:

NAVAL ENGINEERS.

		Rank.
Fireman, 2d Class,	Fireman Mechanic, 2d Class,	Seaman, 3d Class.
Fireman, 1st Class,	Fireman Mechanic, 1st Class,	Seaman, 2d Class.
Leading Fireman,	Leading Mechanic, . . .	Seaman, 1st Class.
Chief Fireman,	Chief Mechanic, ...	Petty Officer, 3d Cl.
Machinist, or Artificer, ...		Petty Officer, 2d Cl.
Chief Machinist, or Chief Artificer, ...		Petty Officer, 1st Cl.
Assistant Engineers, ...		Ensign, or Sub-Lieut.
Engineers, ...		Lieutenants.
Chief, or Staff Engineers, ...		Lieut.-Commander.
Fleet Engineers, ...		Commanders.
Engineers-in-Chief, or Inspectors General of Naval Engineering, ...		Captain.
Director-General of Naval Engineering, . . .		Rear Admiral.

The oilers and water-tenders would not be separate ratings; the men for those duties would be selected from the chief mechanics and machinists. The pay of the fireman-mechanics, leading and chief mechanics, should be 25 per cent. more than the pay of firemen, leading firemen and chief firemen.

The above-named ratings of men and petty officers would comprise the engine-room men only. But the "Corps of Naval Engineers" under the control of the naval engineer officers should include the whole of the shipwrights, armorers, electricians, dynamo tenders, torpedo artificers, blacksmiths, plumbers and tinsmiths; and the whole of the *materiel* of the ship and all its arms and machinery should be entirely in the care of the engineer officers of the ship. (Appendix C, page 51.)

This UNIFICATION of the whole of the mechanics under the principal engineer officer of the ship would enable the whole of the mechanics to be concentrated on the repair of the most important defects, either of the ship, the propelling machinery, the gun mountings, torpedo machinery or electrical plant. And all the defects in all the *materiel* would be made good much more rapidly if there was a supreme head of the mechanical work, for then there could be no conflict of authority or friction, as there would be only one united body, instead of a large number of petty little departments to squabble about where each one's

authority begins or ends. The captain would hold the principal engineer officer responsible for the efficiency of the whole of the *materiel*, and the engineer officer would have the means and the power to sustain that responsibility. There would be a fair division of labor and responsibility. The captain and line officers would navigate and fight the ship, they would represent the nation, and deal with all international questions. The naval engineers would keep the *materiel* in repair, propel the ship, and fight as required, on board or ashore, under the orders of the captain or line officers.

I recognize as much as any man the difficulty of making a radical change in the *personnel* of such a conservative institution as the navy of any country is. But the statesman who is responsible for the organization of a navy should not be dominated by the ideas and practices of a dead past. His first and his last duty is to consider the efficiency of the navy for the hour of battle and for the week afterwards.

The naval organizer has to consider all sides of a many-sided question, and to determine the correct position and organization of the naval engineer corps he must study the position, duties and organization of the line officers.

The responsibilities of the captain and line officers are so great, it is necessary for them to know so much of a hundred things altogether outside of their ship, that they surely have no time to spare to play with hammers, files and oil cans in their endeavor to become practical mechanics.

It is necessary that the line officers should know the political state and condition of foreign countries, the state and tendency of commerce and local trade abroad, the condition of foreign navies, the strength or weakness of individual foreign ships, the capacity of foreign ports and the armaments of foreign seaboard fortresses, so that they may become broad-minded, capable, prudent but dashing naval commanders. Captains are not immortal, and in future wars the casualties may be so great that the command of ships may have to be taken by junior officers. How necessary is it then that the line officers should become acquainted with the most important portion of their duties—the duties of command—whilst the preservation and repair of the *materiel* is delegated to those officers who have a special aptitude and who have had a special training for the most efficient performance of those duties.

The duties of the executive or line officer are of such a varied and important nature that if they are to be properly learnt and properly performed those officers cannot have time to learn the details of engineering

as applied to steam propulsion, torpedo and gun fittings, electric light, etc.

The capacity of most men is limited, whether they be line officers, engineers or politicians. We have very old authority that there is "No royal road to learning." Yet not a few people on the European side of the Atlantic think it is only necessary to call a man a naval captain and then he instantly becomes endowed with a receptive capacity which will enable him to acquire as much knowledge of a difficult subject in five minutes as an ordinary man would acquire by five years' study and practical experience.

Not long ago a distinguished naval officer stated that the captain of a man-of-war should not only be able to order the engineer to repair a broken crank-shaft, but that the captain should be able to direct the engineer how to do it. Is this a specimen of modesty or of what? If ships had never been lost by bad navigation and worse pilotage we might imagine that the naval captains who belonged to the same navy as the speaker were very capable men who may possibly have sufficient time to study some practical engineering. But unfortunately ships have been lost by the ignorance and inefficiency of their captains and navigating officers, and before the executive officers occupy themselves with engineering it would be well for them to become perfect in their own special duties. Surely, if it were necessary for a captain to tell the engineer how to mend a broken shaft, it is only to be supposed that it would also be necessary for the engineer to tell the captain how to navigate and fight his ship. Such a confusion of duties would, however, be only fit for the inmates of a lunatic asylum. The engineer most assuredly should know better than the captain how to mend his broken crank-shaft, and the captain should know better than the engineer how to navigate and fight his ship.

There is no reason why the Engineer should not have as much zeal for his work, and feel as much patriotism and pride in the honor of his flag as any other naval officer; and there can be no doubt but that they are as much to be relied on to perform their duties as any other officers. But surely they must be fully trusted and given full control of all the machinery on board ship and full control of their own staff, otherwise it is impossible for them to perform their duties properly. In the British Navy, thirty years ago, the stokers were stationed at heavy guns, and received extra pay as trained men. At that time they were so frequently called out of the engine-room for gun and sail drill, cleaning copper on masts and sides, boat work, etc., that the engine-room work

was quite neglected, the men were overworked, and the engineer officers driven to despair. The state of affairs got so bad that at last the Lords of the Admiralty had to interfere and issue orders that the stokers should not be drilled or qualify for the rating of "trained man," and further stringent orders were given that the men should not be taken out of the engine-rooms without the knowledge and consent of the engineer officers. This was most beneficial to the engineer *materiel* of the British Navy as well as to the *personnel*. But that was when the engineer force formed but a small percentage of the total number of the ship's company; and, further, it was when the duties of the engine-room did not require such high skill and ability and such great physical strength and endurance as are required now. It is probable that the British Navy has more men engaged in tropical service for long periods than any other navy. And certainly the heat that the naval firemen have to endure in modern men-of-war is far in excess of the heat of the fire-rooms of the fastest mail steamers running in any part of the world. I well remember the chief engineer of an American steamer visiting my ship in the harbor of Acapulco. We had come into harbor the day before, our fires had been banked and we had windsails up and the ventilators trimmed to catch the breeze. After walking round the engine and boiler rooms that American engineer quietly remarked, "Well, you must have one consolation in this ship—you have not much to fear in the future, for whatever you do in this life, you can't get into a much hotter place in the next world than what you have got here." He further informed us that the maximum temperature of his engine-room when running from Panama to San Francisco was 27 degrees below the average temperature of ours.

I merely mention this to show one of the differences between the condition of men-of-war and merchant steamers. As years go on the differences become greater instead of less. And in my opinion it is absolutely necessary that means should be taken to provide healthier conditions for the engine-room mechanics and firemen on board men-of-war. This can be done only by giving them fresh air and daylight by spells of deck duty. They cannot have spells of deck duty and drill unless their numbers are largely increased. Their numbers cannot be largely increased if they are not drilled up for fighting purposes, otherwise the fighting power of the ship would be reduced; and therefore it is evident that for real fighting efficiency and for speedy repair of the ship after an engagement, the engine-room staff must be:—

1. So large as to be far in excess of the staff of a merchant ship of similar horse-power.

2. It must be in excess of the ordinary requirements of a man-of-war during peace time. Thus, if the present number of mechanics and firemen of a given ship be 100, then according to my views the number would be increased to 200, and the marines and idlers would be reduced by 100 men. The naval engineers for deck duty would therefore equal in number those employed below.

3. The deck party of engineers and the engine-room party of engineers would change duties every fortnight, say, on every alternate Monday at noon. The deck party thus becoming the engine-room party, and the engine-room party going on deck.

4. When steaming the engine-room party of engineers should never be called upon to do drill of any kind, or to do any deck work whatever. They should never be employed on any duty when off watch, and they should never be worked in the engine-room "watch and watch" for more than 24 hours.

5. When in port executing ordinary repairs, cleaning bilges, etc., the engine-room party should never be employed on deck or do drill of any kind until the engineer officer in charge has reported to the captain that the machinery is in all respects complete and ready for war service at a moment's notice.

6. When, owing to excessive heat or hard steaming in the tropics, etc., the engineer officer considers that it is necessary to increase the number of firemen in each watch, or to increase the number of watches from three to four, so as to give the firemen a "longer spell off," he will make written application to the captain for as many of the naval engineers from the deck party as he requires.

7. After an action or any disaster, when many defects may have to be made good, the engineer officer should make written application to the captain for the whole of the naval engineers of the deck party, as well as the engine-room party, to be placed at his disposal entirely until all defects are made good and the ship is once more ready for fighting. Until the defects are made good not a single man should be employed in drill or in doing any deck duty whatever.

On a former page I have referred to the numerous and important duties of the executive or line officers. Let me again refer to them. The executive officers in the British Navy are supposed to have a thorough knowledge of, 1, seamanship; 2, navigation; 3, nautical astronomy, meteorology, etc.; 4, marine surveying and compass correction; 5, pilotage; 6, gunnery, infantry drill, machine guns and field artillery; 7, torpedoes, automobile and stationary; 8, naval tactics; 9,

fortification, and other military subjects, such as transport and commissariat duties; 10, naval and military history; 11, international law; 12, foreign languages—French, German, Spanish, Italian.

In addition to these very necessary subjects, they are supposed to acquire a good knowledge of marine engineering and naval architecture, pure and applied mathematics, physics and chemistry. It is almost a matter for surprise that they are not required to have a profound knowledge of surgery, medicine, geology, mineralogy and theology.

Surely there can be no more necessity for the executive naval officer to spend his valuable time in studying naval engineering and architecture than there is for the skillful surgeon to study steel-making and the cutlery trade because he uses instruments made of steel.

Certainly if the executive officer can acquire a thorough knowledge of the twelve subjects above named, which are absolutely necessary for the efficient performance of his proper duties, the engineer officers may be trusted to be able to undertake the care, the management and repair of all the machinery, gunnery, torpedo and electrical fittings on board ship, and of the ship itself; and certainly the engineer officers should have control of the whole of the mechanics on board. Not only that, but the engineer officers should be drilled at heavy gun, rifle and battalion drill, so that they may be in full control of their men.

The number of engineer officers has been cut down very low in the British Navy and still lower in the U. S. Navy. I say they have been cut down dangerously low, because in war time a very slight accident may disable the two or three engineer officers and leave the engineer department entirely *headless*. And I can conceive nothing more dangerous than trusting the machinery of a man-of-war to the hands of mere mechanics, who have not sufficient scientific knowledge to utilize their own practical experience.

So far as the experience of the British Navy goes during late years, its efficiency has increased in proportion to the development of the engineer branch. The English Admiralty recognize this fact. For a long period I worked to get the engineer officers drilled, (see extracts from my letters to the British Admiralty dated 1877 and 1885 in the appendix) and at length an Admiralty circular, No. 17 N, was issued on the 11th March, 1886, ordering that leading stokers and stokers should be trained in the use of arms, etc. Furthermore, the engineer students were ordered to undergo a course of rifle, pistol, cutlass and battalion drill, and they proved themselves to be more than the equals of the other officers in smartness and proficiency in all drills. The great

ability shown by the engineer students in passing their examinations in torpedoes, gunnery and hydraulic fittings, electric light, etc., was a source of astonishment to the very able examining officers.

In concluding this paper, which only glances at some of the salient points of a large question, I would beg leave to state my conviction that the United States system of having an independent Bureau of Steam Engineering is by far the best that can be devised. But I am of the opinion that the Bureau should be heavily manned with good men, and that it should not be overloaded with work. The work of the Bureau should be divided into two branches:

1. The designing and manufacturing branch, having control over the work in the various navy yards and contract work.

2. The examining, testing, and *trustee* branch, whose duties it would be, first, to examine and report on the progress of the work at the various navy yards and contractors' works; second, to test the machinery, etc., on its completion, and to accept it or reject it according to its merits; third, to take charge of all new and old vessels and to keep them efficient (when out of the hands of the navy yards), and ready for active service at a moment's notice. This latter department would then act as an effective check upon the manufacturing department, which latter in some cases, in Europe at least, has been tempted to sacrifice efficiency for cheapness.

The officers of the examining branch ought to be senior to or of higher rank than the officers of the manufacturing branch. When the loss of H. M. S. Megara, in 1870, caused a committee to be appointed to inquire into the matter, I made proposals similar to the above; and at length this plan has been recently adopted by the Admiralty placing the steam reserve officers under the Admiral Commander-in-Chief at the various ports, instead of their being, as formerly, under the orders of the Admiral Superintendents of the various navy yards, who were *officially* the heads of the ship-building yards and engine factories.

As regards the charge of the machinery when it is on board ship, the whole of the hydraulic gear, the turrets, electric light, air-compressing machinery and torpedoes, torpedo-boats, steam capstans and steering engines is in the charge of the English naval engineer officers. The captain, therefore, has always a body of scientifically trained and practical mechanical officers to hold responsible for the efficiency of all the mechanical appliances on board. The hull of the ship also, as regards its interior parts, double bottoms, watertight doors and compartments, pumping and flooding arrangements, etc., are all in the charge of the

engineer department; and I maintain that no navy can be truly efficient for fighting purposes where this system is not fully carried out.

No half and-half measures will avail. The executive or line officers must be the navigating and the fighting officers *par excellence*; they must have the control of the weapons and of the men who use them. But the engineers must have the sole care of the material and of the mechanical *personnel* to keep the machinery in fighting order, and to repair it after an engagement or disaster, and thus to prepare it for fighting again.

There must be no division of the mechanics on board, as at present, some under the carpenter, some under the gunner, and some under the engineer. All must be under the engineer if there is to be fighting efficiency.

So far the object of this paper has been to heap additional work, drill and responsibility on the engineer officers. I must now say something as to the necessity of bettering the conditions of the engineer officer's life. More than any other officer, the engineer requires good cabin accommodation, where he can rest at any time. For long periods I have had to keep "watch and watch," four hours on and four hours off, and so I have known what it is to require quiet cabin accommodation. Furthermore, all the engineer officers should be ward-room officers—that is, they should not mess in the steerage.

As regards title and relative rank, I cannot but think that as the English Navy has largely borrowed of the United States Navy in years gone past, so now the United States Navy may with advantage borrow from the English Navy somewhat. Thus the engineer officers on first entry for actual service afloat, after leaving the training college, should receive the title of "assistant engineer" with rank of ensign. After four years' service, and passing the necessary examination, the rank of "engineer" should be obtained with the relative rank of lieutenant. The next step would be that of chief engineer with relative rank of lieutenant-commander. And then the next step would be that of fleet engineer with relative rank of commander. The officers appointed to Dockyards and to the Navy Department of Washington should have the title of "engineers-in-chief," or inspectors-general of naval engineering with the relative rank of captain, and the chief of the bureau should receive the title of director-general of naval engineering and should bear the relative rank of rear-admiral.

FORMATION OF AN EFFECTIVE NAVAL RESERVE.

So far as I can see, no step has been taken to form an effective reserve of the engineer force for the United States Navy, so as to provide for a war with any great naval power. Whether such an effective reserve is necessary depends upon the foreign policy of the government of the United States. That it is necessary for the British Navy is, in my opinion, beyond all question, and the method I have proposed for the establishment of such a reserve is shown in the Appendix C, pages 52–55.

My aim has been to obtain efficiency for the hour of battle and for the week afterwards, and that object I pursued during the time I was in the English Navy; and it is still my object, although I have no personal interests to serve, as I have neither relatives nor friends in any navy. I know that my views are not approved by many officers of all classes. On the other hand, I know that many officers who have seen some sea fighting agree heartily with these views.

I say there is in these days no room on board a modern man-of-war for the man who is only a marine and nothing more, or only a fireman and nothing more, or only a mechanic and nothing more. Whatever he may cost to obtain, the man for the naval engine-room must be a stoker, mechanic, marine gunner, similarly as the English man-of-war sailor is a seaman, a gunner, a rifleman, a torpedoist and a diver.

I can only hope that these few remarks will be amply discussed and receive the severest criticism of the members of the Institute, and that those that do me the honor to oppose my views will remember that I write not for the piping times of peace and fair weather cruising, but for THE HOUR OF BATTLE AND THE WEEK AFTERWARDS.

APPENDIX A.

EXTRACT FROM LETTER BY GEORGE QUICK TO ADMIRALTY, DATED ——, 1877.

ENGINEER SERVICE OF THE ROYAL NAVY.

Suggestions:—*Engineer Students.*—The present method of educating the students in mechanical skill and pure mathematics is all that can be desired, but I think from my own knowledge of many of those who have been students that more time and attention should be given to drawing and physical science than at present.

Drill.—There is, however, another point of great importance to which I have never seen any allusion made; that is, that for the due performance of his duty it is necessary that the engineer officer should at an early age acquire some idea of command, not of a ship, but of the men under his control. To give that idea of command there is, in my opinion, no method of education so effective as military drill.

I venture, therefore, to suggest that a portion of time should be devoted every week to the instruction of the students in rifle, cutlass and heavy gun drill, even if the time of study has to be increased by six months—that is, from six years to six years and a half; although I do not think that is absolutely necessary, as I am of opinion that the term of mere mechanical labor in the workshops might be reduced with advantage, for from my experience of the service I am led to conclude that a military spirit and officer-like feeling would tend to the preservation and proper use of the machinery of the fleet far more than any manual skill in mechanical labor possessed by the persons in charge of it.

With engineers having a military spirit and officer-like feeling, there would be every exertion made to preserve the machinery in the best working order. It is the prevention of the necessity for repairs, combined with the capacity to effect repairs after an action, in the shortest time, that constitutes the highest art of the seagoing naval engineer officer.

The proposed system of drill would also induce a more systematic routine in the engineer department than is general at the present time. And in the event of large numbers of the combatant officers being disabled in action, ashore or afloat, sick or absent in the vessels taken from the enemy, landing parties, etc., the engineer officers would be available for directing, under the orders of the commander of the ship, the mechanics, stokers and domestics, whom I suggest should also be trained to the use of small arms.

Drill of Mechanics, Stokers and Idlers.—Taking into consideration the very large proportion that the mechanics, stokers and other civilians bear to the pure blue-jackets and marines in modern ships of war, it appears to me necessary that so large a number of persons should receive some instruction in rifle, cutlass and gun drill.

If the plan suggested be carried into effect I believe it will positively increase the efficiency of the men in the performance of their ordinary duties, for there can be no doubt but that military drill, teaching the habit of physical obedience to the word of command, is of great benefit physically to all who are brought under its influence.

APPENDIX B.

EXTRACT FROM LETTER BY GEORGE QUICK TO ADMIRALTY, DATED NOVEMBER, 1885.

ENGINEER OFFICERS.

1. Having regard to the vast increase in the power of the machinery of modern ships, and the greatly increased range of the duties and responsibilities of the engineer officers, and the large number of men under their control, I am of opinion that there is an urgent need for a considerable change in the rank of these officers.

From the Navy List of the 1st October, 1885, it appears there are now of ships built and building 92 vessels of 3,000 indicated horse-power and upwards, with engine room staff of from 32 to 118 men, exclusive of engineer officers. This gives an average of 5,925 indicated horse-power and of over 69 men under the control of every chief engineer of these ships. The total power of these 92 ships is upwards of five hundred and forty-five thousand indicated horse-power for propelling engines alone, exclusive of all the numerous auxiliary engines for steering, hoisting purposes, electric light, turret work and torpedo machinery. Or, excluding all ships under 4,000 indicated horse-power, there remain 73 ships of an average of 6,600 indicated horse-power and with an average engineer staff of over 75 men.

For the control of this vast total of more than half a million of indicated horse power of machinery and of upwards of six thousand four hundred men there were on the 1st October last on the active list of the Navy (excluding inspectors of machinery) only 19 officers of the relative rank of commander, and none of the relative rank of lieutenant of over 8 years' seniority, all the other chief engineers on the list except the above mentioned 19 being junior to lieutenants of 8 years' seniority.

Such a scarcity of officers of the relative rank of commander does not exist in any other branch of the public service, regard being had to the total number of men belonging to the department, to the enormous money value of the material under the control of these officers, and to the vast importance of the duties of the department from a purely fighting point of view.

In modern warfare the breakdown of the engineering department during action means the total loss of the ship.

2. That the Navy has hitherto existed without engineer officers

holding higher rank than they do is no argument in favor of their retaining their present low position. For, in fact, the number of engineer officers in the relative rank of commander was much larger in years gone by than it is now, or than it is ever likely to be again under the existing regulations. For, in the course of a few years when all the engineer officers of the rank of engineer will be qualified for the rank of chief engineer, the rate of promotion to the rank of chief engineer will be much less than it is now; and few engineers will be promoted before arriving at 44 to 45 years of age. I have not the slightest doubt but that the engineer department is quite as efficient as any other department in the Navy (if not much more so), and that it is far more efficient than the steam department of any other navy in the world; but I am of opinion that it could be made very much more efficient for combatant and all other purposes by the changes I shall propose to be made.

3. I have no hesitation in asserting that the very small improvements which have been made during the past 8 years in the position of the junior engineer officers have been productive of great benefits to the efficiency of the service, and I am confident that any other improvements which are made in the position of the engineer officers generally will be amply compensated by a further increase in efficiency. It is very certain that the duties of the stokers are of the most arduous and disagreeable nature, very trying to the health, temper and discipline of the men. There is no romance or interest in shoveling coals in the bunkers or into the furnaces, nor in cleaning boilers, bilges, etc., like there is in the blue-jacket's work on deck. And the management of the men under these circumstances is very frequently a most difficult task for the engineer officer of the watch, or the one who has charge of the men for the day. I cannot but speak in terms of the highest praise of many of the stokers I have known, men who have worked hard, were careful and cautious in the performance of their duties, strove to improve themselves as workmen, and gave no trouble to the engineer officers. But I have known many other cases in which the stokers have given an immense amount of trouble to the engineer officers, whilst they were cunning enough to keep a good "deck character" by not breaking their leave and by being very obsequious to the ship's police. It has been, as a rule, very difficult to get such men punished for crimes in the engine-room, because their good "deck character" saves them; and then, when it begins to be understood that the engineer officers cannot get the men punished for engine-room offenses, discipline and

ready obedience in the engine-room are very difficult to maintain. I know one case in which an engineer officer having reported a stoker for having been asleep when on duty, the unfortunate officer was accused of neglect of duty in allowing the man to go to sleep, but the stoker was not punished. This decision led to much insubordination amongst the other men, and it was not until another engineer officer had laid a complaint before the Admiral on the station and obtained satisfaction that matters began to go on in a satisfactory manner in that ship's engine-room.

During a time of peace when only ordinary cruising duties have to be performed the maintenance of discipline is, as I have endeavored to show, in some cases very difficult; and it appears to me that in action and in times of great danger it may be, in some cases, utterly impossible for discipline to be kept, if the engineer officers have not higher rank and greater legal control and power over the men than at present.

In two cases of imminent peril that I know of, the stokers remained in the stokehold doing their work quickly and quietly; but, in two other cases I have heard of, the engineer officers had to prevent the men by force from bolting up the ladders to get out of the engine room and stokehold.

4. This brings me to an important point as to the training of stokers and engineer officers. The immense influence of military drill upon men generally to improve their discipline and to make them better workmen in all occupations of life is strikingly shown by the superiority of the man who has been a marine or in the army, when entered as a stoker, to the ordinary men who are entered as stokers without any military drill. I have for many years noticed this, and having regard to the very large number of stokers and other undrilled and unarmed persons on board English ships of war, I have endeavored to get a certain amount of military drill for the stokers *on first entry into the service*, and some little practice of the same kind afterwards at sea.

If this were done there would be less objection to the engine-room staff of stokers being increased in numbers. That it would improve their discipline and their work in the engine-room I am also completely convinced by what I have learnt from French and German manufacturers and large employers of labor, of the vast improvement in the character and conduct of their workpeople since the institution of compulsory military service in those countries.

5. The duties of the engineer officers as well as of the stokers have become of a far more combatant nature than they were formerly; and

I consider it is most desirable that the junior engineer officers should be required to undergo a course of military drill.

This is no new idea of mine, as I drew up a paper on the subject in 1877-8 for Admiral Moresby, who was then captain of H. M. S. Endymion. But it was not popular with the engineer officers nor with stokers a few years ago. A great change of opinion on this point has, however, taken place, I believe, and I have been told by stokers who have been employed in torpedo-boats, etc., that they felt very strongly they ought to have instruction in the use of arms to defend themselves, and that arms ought to be supplied to them. They also said that they thought they ought to be taught at least how to discharge the torpedoes, in case all the deck people of the boats should be killed or disabled. I do not think it is desirable to attempt to make men "Jacks of all trades," but as modern warfare requires so many mechanical operations to be performed, I am decidedly of opinion that the whole engineering staff should have a certain amount of drill in the use of arms. It has been proved by experience that as a rule the well-drilled man (soldier or sailor) will make a good workman, and it has been equally well proved that the good workman will drill well and quickly and make a very good shot. Cleaning and polishing brass work on deck I do not consider as drill, and stokers should not be employed at such work unless the complement of stokers be largely increased.

6. Up to the present time engineer officers have been "civil" officers. I am of opinion that the time has arrived when they should be made military officers, similarly as the navigating officers are, and that they should wear similar uniform to the navigating officers, but with the distinguishing marks of the engineer officer as regards velvet between stripes, etc.

This change of uniform alone would largely increase their power and authority over their own staff in the engine-room; but I am of opinion that the principal engineer officer on board a ship should have the power of awarding minor punishments to his men direct, or at least of bringing the men directly before the captain instead of bringing them as now before the first lieutenant or commander.

This removal of the engineer officers from the civil to the military branch is the greatest change I have to propose. It has been recommended before by an Admiralty Committee, and I know that a very large number of the engineer officers are desirous of it solely for the purpose of obtaining increased efficiency in the engineer department.

7. Whether the engineer officers are removed to the military branch

or not, I consider it is most desirable that the following alterations in the titles and in the relative rank of the engineer officers should be made:

1. That the head of the engineer department at the Admiralty, whether the appointment is held by a civilian, as at present, or by a naval engineer officer, should receive the title of "Director-General of Naval Engineering" or "Director-General of the Engineer Department of the Navy," and that he should, if a naval engineer officer, hold the relative rank of rear-admiral, whilst holding that appointment.

2. That the titles of chief inspector of machinery and inspector of machinery be abolished, and that the officers now in those ranks should receive commissions as "engineer-in-chief" with the relative rank of captain in the Navy, according to date of commission. The seniority of these officers to date from the date of their first commission as "inspector of machinery." Thus if an officer was promoted to the rank of inspector of machinery in 1875 and to chief inspector in 1880, then his seniority as an "engineer-in-chief" would date from 1875.

The number of "engineers-in-chief" should be 12, and they should be appointed for service as follows: One for each reserve at Portsmouth, Devonport, Chatham, Malta (4). One for each dockyard at Devonport, Malta, Bermuda, Hong Kong, Halifax, Cape of Good Hope (6), and 2 others available for employment on special service, at the Admiralty, or in large fleets, or otherwise as required.*

3. That all chief engineers now on the Active List, of and above 7 years' seniority, should receive commissions as "fleet engineers" and have relative rank with commanders in the Navy according to date of commission.

Those few "chief engineers" who now rank with commanders to have their commissions as "fleet engineer" antedated, so as to give them the same seniority relative to commanders as they have at present. Thus the seniority of the present senior chief engineer in the Navy would be dated as "fleet engineer" the 27th September, 1881.

*Those officers who are now Chief Engineers of the Dockyards at Portsmouth, Chatham and Sheerness must, in the course of a few years, become "inspectors of machinery" on the present system, or "engineers-in-chief" on the proposed system. I am of opinion that it would be of advantage that the officers now holding those appointments should have the rank of "engineer-in-chief" conferred on them immediately.

I am of opinion that the principal engineer officer of every ship of 3,000 indicated horse-power and upwards, or which has an engine-room complement of 40 men and upwards, should not have a lower relative rank than that of commander. As there are 92 of such ships built and building, and as this number is likely to be increased, I am of opinion that there should not be less than 100 engineer officers of the proposed rank of "fleet engineer." These would be employed somewhat as follows:

For ships built and building of 3,000 I. H. P. and upwards .	80
For the Admiralty	2
For reserves at Portsmouth, Devonport, Chatham (3 at each)	9
For dockyards at Portsmouth, Devonport, Chatham and Sheerness	9
For dockyards at Gibraltar, Jamaica, Esquimault	3
For Victoria and Albert and Osborne Royal yachts . . .	2
	105

From the foregoing it is evident that there will be plenty of appointments open for the proposed number of "fleet engineers." This rank of fleet engineer should be granted:

(*a*) To those officers who have 7 years' seniority as chief engineer and 20 years' total full-pay service in all ranks.

(*b*) To those chief engineers who have two years' full-pay service as such, and shall have distinguished themselves in the presence of an enemy, or for conspicuous professional merit, such promotions to be "special" and not to exceed the rate of two in any one year after the first year of the introduction of the rank of fleet engineer.

(*c*) The total number on the Active List at any one time of the fleet engineers holding that rank by such special promotion shall not be more than 20.

(*d*) The Admiralty to have the power during the first year of the introduction of the rank of "fleet engineer" to give ten special promotions to that rank.

(*e*) As a rule two or more fleet engineers should not have seniority of the same date.

(*f*) The Admiralty to retain power to specially promote chief engineers to the rank of "engineer-in-chief" for very distinguished service in the presence of an enemy, or for great professional merit and services, similarly as they have at present; that is, after five years' service as chief engineer.

8. In order to have one uniform title in the navy to indicate or distinguish one particular degree of relative rank throughout all branches, I have to propose that those "chief" engineers on the Active List who may not be immediately promoted to the rank of "fleet" engineer should receive commissions as "staff" engineer with the relative rank of "staff lieutenant" according to date of commission. The date of the seniority of the "staff" engineers to be that of their present seniority as "chief" engineer. Thus a chief engineer whose seniority is, say, 1st July, 1882, would become a "staff" engineer with seniority of 1st July, 1882.

9. *Engineers.*—The position of the engineer officer of the rank of "engineer" requires to be greatly improved. As previously shown, there are 92 ships built and building of 3,000 indicated horse-power and upwards, and with engine-room complements of from 38 to 112 men, and there are 83 ships of under 3,000 indicated horse-power and over 1,000 indicated horse-power.* It appears to me of the utmost importance that at least the two engineer officers next in authority to the principal engineer officer of a ship of over 4,000 indicated horse-power should have the relative rank of lieutenant with seniority according to date of commission, and that the engineer officer in charge of small vessels under 1,000 indicated horse-power should also have the same rank. There can be no doubt that the duties and responsibilities of engineer officers are increasing more rapidly than those of any other class in the service.

I have, therefore, to suggest that all engineer officers now on the Active List as "engineers" should rank with lieutenants under eight years' seniority according to date of commission. They would thus be always junior to staff lieutenants (if that title be adopted) or to lieutenants of eight years' seniority. The number of officers required for the service must be determined by the number of ships built and building. At present, I believe that about 300 engineer officers of this rank of "engineer" are required for active service.

10. *Assistant Engineers.*—All assistant engineers of whatever age or length of service are, according to the present regulations, junior to sub-lieutenants and all assistant paymasters. This is felt by them to be a very great hardship, and I am of opinion that assistant engineers should rank with sub-lieutenants according to date of commission.

*With engine-room complements of 55 men and under; and there are 166 vessels having less than 1,000 indicated horse-power.

APPENDIX C.

EXTRACTS FROM PROPOSED ORGANIZATION OF A COMBATANT CORPS OF ROYAL NAVAL ENGINEERS, WITH AN EFFECTIVE RESERVE OF NAVAL OFFICERS AND MEN, BY GEORGE QUICK, FLEET ENGINEER, DATED 29TH JANUARY, 1887.

DISCIPLINE AND DRILL OF THE STAFF OF THE STEAM DEPARTMENT.

From the Navy List of 1st October, 1886, it appears there are now one hundred (100) ships, built and building, of 3,000 I. H. P. and upwards, with engine-room staffs of from 29 to 119 men, exclusive of officers.

This gives an average of over 70 men, under the control of the engineer officer of each of these ships; and an average of 6,222 I. H. P. for propelling engines, exclusive of all other kinds of machinery. The total number of men in the engine-room staff of these ships is 7,066.

Besides these men, there are many others not classed as combatants, such as armorers, blacksmiths, carpenter's crew, plumbers, etc.

Having regard, therefore, to the large number of unarmed and undrilled persons in our ships of war, forming as they do so large a proportion of the ship's company, we would recommend that all these so-called "idlers" should be exercised in the use of rifle, pistol and cutlass; and also in the case of artificers and stokers at heavy gun drill, instead of their valuable time being expended in sail drill, as at present.

The immense influence of military drill to improve discipline and make better workmen is strikingly shown by those men who have been marines, when entered as stokers, compared with the ordinary men entered. That it would improve the discipline and work in the engine-room is undoubted.

The duties of stokers are of the most arduous and disagreeable nature, very trying to health, temper and discipline, and their management by the engineer officers is often a difficult task, even in times of peace; in action, and in times of great danger, it may be utterly impossible for discipline to be maintained, unless the engineer officers be given greater legal control and power over them. More especially is this apparent when we consider the conditions under which a future naval action would be carried on, so far as regards the engine-room department; with all water-tight doors in engine-rooms and stokeholds closed, the stokeholds under forced draught, necessitating the securing down of all

hatches, the only communication with the executive officers being by means of a voice-tube to the bridge or conning tower.

It is therefore necessary that the principal engineer officer should have the power of awarding punishments of a minor nature to the men of his department, and referring graver offenses to the captain, instead of laying every little complaint before the senior executive officer as at present. The junior engineer officers should also be instructed in heavy gun drill as well as in rifle, pistol and cutlass drill in order to exercise their own men, so that the engineer officers might, under the direction of the captain, have over their own staff similar control to that exercised by the executive officers over the seamen.

Moreover, in the case of future warfare, it is reasonable to anticipate that some of the enemies' ships would be captured. Such ships would either have to be destroyed, or prize crews placed on board to take them to a British port. Such crews must necessarily contain a large proportion of officers and men of the steam department, which could not be arranged, under existing circumstances, without crippling the fighting power of our own vessels.

This consideration points out the necessity of largely increasing the proportion of ranks and ratings of this department, in the complements of our men-of-war. In times of peace, this increase of numbers might partly be employed with advantage in their usual duties, the present complements being, in many cases, barely sufficient to maintain the efficiency of the department; but in order to usefully employ the whole of such increase, it would probably be found necessary to detail them for other duties. It is therefore thought that the exceptionally good conduct of the engine-room staff, under the ordinary circumstances of the service, justifies the experiment being made of forming a part of the "guard" of trained stokers, instead of Royal Marines. By thus relieving a portion of the engine-room staff of the confinement entailed by their ordinary duties, and giving them more open-air exercise, the effect on their health would be most beneficial.

THE FORMATION OF THE WHOLE OF THE ENGINE-ROOM STAFF AND SHIP'S ARTIFICERS INTO ONE BODY FOR THE MAINTENANCE AND REPAIR OF THE SHIP.

Within the last fifteen years the battle-ships of the Navy have undergone vast changes in their construction and armament, more especially as regards the number of fighting machines fitted on board, such as breech-loading guns and Vavasseur gun-carriages; torpedoes with

above-water and submerged discharging tubes; torpedo pressure pumps and air reservoirs; electric lighting machinery, both for search lights and internal lighting; hydraulic engines for revolving turrets, and hydraulic loading gear for the guns; also steering and capstan engines and ventilating machinery.

For the preservation and repair of these machines there are various ratings of artificers, some under the direction of the gunnery officer, some under the torpedo officer, and others under the engineer officer, whilst there is the carpenter's crew for the repair of the hull.

But where there is such a divided responsibility as at present, it is impossible that the work can be carried out, and repairs executed in a thoroughly practical and efficient manner, especially as neither the gunnery nor torpedo officers have received any practical mechanical training. Neither can this machinery be kept in a thoroughly efficient state at the smallest possible cost, under existing circumstances; for, in order that the work done by these artificers may be efficiently carried out, they should be under the supervision of officers who have received a thoroughly scientific and practical training, and who can, when necessary, show them how the work should be done.

In order, therefore, to combine the efficiency and economy in utilizing this large staff which is essential to the thorough efficiency of our fighting ships, it is necessary that the whole of the artificers of all classes—armorers, blacksmiths, plumbers, shipwrights, stokers, tinsmiths, lamp trimmers, etc., (except coopers)—should be merged into one body under the engineer officers,* and forming the corps to be called the "Royal Naval Engineers;" the different ratings therein, with the various rates of pay, to be retained as at present, or be modified in such manner as may hereafter be determined by the Board of Admiralty.

The engineer officer of the ship should be held solely responsible to the captain for the preservation and efficient working condition of the whole hull, engines of all descriptions, guns, gun carriages, hydraulic gear, torpedoes, torpedo gear, electric light, and all other mechanical appliances on board, and for all spare gear and stores appertaining thereto.

By thus placing all stores under the charge of the engineer officer, needless duplication would be prevented, and a reduction obtained both in the weight of stores carried and in the space occupied, together with simplification of the store accounts.

*There is no doubt that if this large staff were placed at the disposal of the engineer officers, the number of defects from ships in commission required to be made good at the dockyard would be largely reduced.

It is considered that by conferring the name, style or title of "Royal Naval Engineers" on all the artificers, mechanical workmen and stokers in the Navy, it would be a very great inducement to smart and able young mechanics to join the service in much larger numbers and for the present rates of pay. This view is confirmed to a great extent by the class of men found willing to join the corps of Royal Engineers.

It is also desirable to establish the rating of "mechanic writer," who should be capable of keeping accounts and writing a good hand; one or two being included in the complement of each ship (according to size), and thus relieving the engineer officer of much clerical labor, and enabling him to devote greater attention to the personal supervision of his staff. All men of the corps, possessing the necessary qualifications, to be eligible for this rating.

PROPOSALS FOR THE FORMATION OF AN EFFECTIVE RESERVE OF ENGINEER OFFICERS.

In 1870 Mr. Childers, who was then First Lord of the Admiralty, abolished the reserved list of executive officers as being utterly useless, and made them all retired officers.

Yet, an efficient reserved list is required, and the formation of one is not an unsolvable problem if a sufficiently broad view be taken of the subject and of the requirements of the Empire. Indeed, the institution of this reserved list of efficient officers of moderate age is, in the case of the engineer officers, an Imperial necessity. In the "Royal Naval Reserve" there are only two engineers (their commissions bearing dates May, 1865, and February, 1882). In 1877, when there was a large demand for engineer officers and artificers to man the reserve fleet, it was found almost impossible to obtain them; and although some officers were obtained from the mercantile marine and the large engineering firms, they would have been of little use at sea until they had gone through a long course of training on a modern man-of-war. If war were actually declared against any great naval power, or combination of naval powers, few merchant service engineers would be found to join,* and, if they did, they would be comparatively useless owing to their want of training.

And although we have on the retired list 180 chief engineers and 200 engineers and assistants, these can in no sense be considered an

*In time of war all sailing merchant ships would be laid up and only steamers employed; consequently there would be a very heavy demand for the services of every seagoing engineer in the mercantile marine.

effective reserve; because, when an officer is retired, he, as a rule, keeps up neither his knowledge nor his interest in the service; and those who have been on the retired list for upwards of two years, without practical experience, are in these rapidly moving times nearly, if not quite, useless, it being necessary for officers to keep constantly in touch with the service to retain their efficiency.

Furthermore, the coast defenses of this country are in a most unsatisfactory state; and any satisfactory scheme for the reorganization of our coast defenses must include, for the service of each station, one or two torpedo-boats, mines for the defense of harbors, etc. The Royal Naval Engineers would be admirably suited for this work,* both for the care and maintenance of the material and for the instruction of men in the reserve and of the naval volunteers.

The establishment of the "Effective Reserve List"† could be easily brought about by the following arrangements, which would give the additional advantage of creating a healthy flow of promotion on the active list, as many officers would willingly go into the "executive reserve" who would not go on the retired list, and thus sever their connection with the service altogether:

1. Entry on the effective reserve list to be by permission of the Admiralty only, and not to be claimed as a right.

2. Officers to be eligible for the reserve list at the following age:

Rank.	Lowest age for permission to enter Reserve.	Age for retirement from Reserve compulsory.
Engineers	35 years.	55 years.
Chief engineers, staff engineers	40 "	60 "
Fleet engineers	45 "	60 "

3. Officers on the reserve list may, on their own application, and by the consent of the Admiralty, be transferred to the retired list at any time before arriving at the age for compulsory retirement from the reserve list.

4. Officers on the reserve list who may be incapacitated for the performance of the active duties of the service shall be retired by direction of the Admiralty as their Lordships may see fit in each case, so that the reserve list may be kept really efficient for active service.

*The French have organized a corps of naval engineers for service on shore, for the purpose of torpedo coast defense, etc.—*See Lord Brassey's "Naval Annual," 1886, p. 479.*

†Invalided officers would not be admitted to the "Effective Reserve List."

5. No promotion to be given to officers on the reserve list, except for war service or active service afloat.

6. Officers on the reserve list to attend at one of the naval ports for a period of two months every two years for practice in naval duties, and to receive information or instruction in new naval appliances, etc.

7. The number of officers on the reserve list to be as follows, and to receive the retired pay due to their age and service, all junior time being allowed to count, together with an allowance of reserve pay at the following rates:

No.		Rate.			Amount.
200	Engineers	at 2s.	per diem	=	£7,300
70	Chief and staff engineers .	" 2s. 6d.	"	=	3,194
30	Fleet engineers	" 3s.	"	=	1,643
300		Annual cost of reserve .		=	£12,137

Average for each officer per annum, £40.

8. Officers on the reserve list to receive while serving at a naval port a subsistence allowance of 3s. per diem, in addition to the above.

9. When officers on the reserve list are employed afloat on actual service they shall receive the full pay of their rank, and will count all time so served for increase of full, half, reserve and retired pay.

10. Officers on passing from the reserve list to the retired list to count half the time served on the reserve list for increase of retired pay.

In consequence of the officers on this reserve list being really effective and available for active service afloat, all costs should be charged to the votes for effective service.

PROPOSALS FOR THE FORMATION OF AN EFFECTIVE RESERVE OF ENGINE-ROOM ARTIFICERS AND STOKERS.

1. All petty officers and men who have completed their service for pension to be medically examined to ascertain their fitness for future service, if required.

2. All petty officers and men found physically fit to be passed into the effective reserve, and remain therein until attaining the age of 55 years, unless they should be found to have become unfit for active service before attaining that age.

3. All petty officers and men of the effective reserve to be placed in three divisions, as nearly as possible equal in numbers.

4. One division of the effective reserve to be called up for exercise and training in the special duties of their service ratings for a period of

two months in every year, preferably from the middle of May to the middle of July, so as to be employed in the reserve squadron during the summer cruise, instead of men being drawn away from the steam reserve as at present.

5. If there be more men in the division of the effective reserve called out than can be usefully employed in the reserve squadron they should be employed in the steam reserves at the principal naval ports.

6. The petty officers and men of the effective reserve should all as far as possible be employed on the special work to which they have been previously trained, and according to the ratings held at the time of their being pensioned.

7. During the time they are called out for training the petty officers and men of the effective reserve should receive the full pay of their ratings and free provisions, in addition to their pensions.

8. In consideration of being formed into an effective reserve, and having to keep a sea kit always ready for immediate service, an allowance of reserve pay, in addition to pension, to be received according to the following scale:

Chief petty officer	4d.	per diem.
1st class "	3d.	"
All other ratings	2d.	"

The charges for provisions and pay in excess of the men's ordinary pensions to be charged to the votes for effective service.

APPENDIX D.

EXTRACTS FROM LETTER SENT BY GEORGE QUICK TO THE ADMIRALTY, 1891.

I beg leave to call the attention of the Lords of the Admiralty to the desirability of forming a corps of Royal Naval Engineers, to be composed of skilled mechanics, for the performance of engineering and stoking work of the navy, and to do guard and deck duty also, in place of the Royal Marines.

It is impossible to overestimate the importance of the speedy repair of the machinery of ships of war after an action, for the gaining of only a few hours in effecting repairs after a battle may decide most important naval operations following upon either a slight or severe engagement.

It is not a good argument to say that English ships will carry as many artificers or mechanics as foreign ships, and that consequently there is

no need to increase the staff of mechanics on board our ships. For if two similar ships engage and each receives similar injuries so that they are compelled to cease fighting and withdraw for repairs—then if one of those ships carries say only thirty skilled mechanics for effecting repairs, whilst the other carries sixty mechanics, the latter ought surely to be in fighting condition first, and must assuredly capture or destroy the former. The naval battles of the future must be in the hands of the seamen-gunners and the drilled firemen-mechanics, for there is no room for or need of the marine on board a modern man-of-war. It is not possible to teach marines in a year or two to become useful mechanics or good firemen and to drill them very quickly into doing all the military duties of marines on board ship. Such a change could not be effected suddenly, but as I advocated the drilling of stokers and engineer officers more than thirteen years ago (and which was adopted only within the last six years), so now I advocate the extension of the system, as the sooner it is adopted the better it will be for the navy.

In the ships of the present day there is no room for the man who is only a "stoker" and nothing more; nor is there room for the "marine" who is only a soldier and nothing more; nor is there room for the man who is a "mechanic" and nothing more.

But what is wanted is the man who can be a fireman, mechanic and marine all in one, and I maintain that such a man can be made if my proposals be adopted, and that there will be but little difficulty in obtaining capable recruits in large numbers if their prejudices or sentiments are duly considered.

I have written on this subject for many years, and on the 29th of January, 1887, I forwarded officially to the Admiralty, through the Commander-in-Chief at Devonport, several copies of a pamphlet on this subject. On page II of that paper it is stated that "It is considered that by conferring the name, style or title of 'Royal Naval Engineers' on all the artificers, mechanical workmen and stokers in the Navy it would be a very great inducement to smart and able young mechanics to join the service in much larger numbers than at present, and for the present rates of pay."

Since my retirement in 1887 I have had many opportunities of ascertaining the feelings of a large number of young mechanics in all parts of the country, and I have found many of them express a strong desire to see the world by taking service in the Royal Navy for a few years as "Firemen Mechanics," providing they were called "Engineers," and providing they had a chance of promotion in case they wished to remain in the Navy.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE SIGNAL QUESTION UP TO DATE.

By Ensign A. P. Niblack, U. S. Navy.

In a recent number of the Proceedings the writer made a futile attempt to solve some of the difficulties of the naval signal question, by proposing a system of day, night and fog signals conforming to the requirements of the American Morse code, adopted some two years ago as the service code; but any attempt to patch up the defects of that code, as applied to naval purposes, is a foredoomed failure, because it possesses just those undesirable qualities which every consideration of theory and practice condemns. The substitution of the English Morse code for the Myer was not regarded as successful, as it seems to have been dropped in turn for the American Morse. This last named was adopted by the Navy Department at the request of the Chief Signal Officer of the Army, in order that the two branches of the military service might communicate in emergencies. The principal reason which led the Army authorities to adopt the American code was, that it being the commercial code, in time of war skilled operators would be abundant from which to recruit the Signal Corps. That reason at least has no bearing on the question from a naval standpoint, for in time of war if there is anything more than another that is not wanted aboard ship it is a landsman with only one talent, and that for working a key. In accepting this allurement, however, the Army authorities left out of consideration the fact that in time of peace, especially now that enlisted men can purchase their discharge, the current is reversed, and the expert signalmen of the Army furnish an inexhaustible source of supply to the commercial demand for telegraph operators. In the Navy we had some such experience with seaman gunners as expert electricians, until the course at Newport was changed. Whether or not the Army author-

ities have made a mistake concerns us only in that if we are to be saddled with a code not adapted to our purposes, and ages behind the times from a naval standpoint, just because the Army has adopted it, then the sooner we can compromise with the Army authorities the better. As it is now we have a code which possesses the sole recommendation that in some remote emergency we can communicate with an Army station. It does not take much cleverness to see, however, that this very desirable thing could be accomplished by requiring only the signal officer and signal men of each ship to know the American Morse code for just such emergencies; but why require the whole Navy for years and years to use it, with all its glaring defects, when the solution is so simple?

The American Morse code is not adapted for naval purposes:

1st. On account of the space letters *c*, *o*, *r*, *y* and *z*, and in the character *and*. The space is bad in the wig-wag, for in the recovery from a *front*, representing the space, it is made so quickly that unless the signal sender is facing squarely (and often he cannot be, in communicating, say, with two adjacent ships or stations at once) it is difficult to distinguish this quick *front* from a dot or dash, as the case may be. In night flashing with winker lights it requires an extra light to make the space signal, or else the use of a very long dash, which is confusing and wastes time. In a display of red and white lights, like the Ardois system, a third color (green) must be introduced, as was attempted in a system proposed by the writer in a recent Proceedings, which plan as there proposed is acknowledged to be a failure. Anything which attempts to utilize the American Morse code is, however, bound to more or less of a failure. In fog signals the space must be indicated by a long dash, which may lead to some confusion, but at any rate wastes valuable time. If these reasons are not enough to condemn the American Morse code for naval purposes, then:

2d. The character *error* is, in this code, seven dots; the numeral *six* is six dots; the letter *p* is five dots. Even if we get around the *error* by substituting some device, still, in some such system as the Ardois, by which all the elements of a character are exhibited in one display, we must have at least six lanterns in the permanent hoist with which to make the numeral *six*. When the Navy Department ordered the eight Ardois apparatus from abroad, a plan of the sixty-four sectors was furnished the makers by which to mark the disks of the signal boxes. It was found impossible to use the American Morse

code, not only on account of the requirements of the *error* and the *six*, but of the impossibility of displaying the space letters. Accordingly a new alphabet and numeral code was invented. In other words, the American code has to have a supplementary code to do its work for it. Now the system of night signaling by means of a permanent hoist of lanterns similar to the Ardois has come to stay. The advantages offered of rapidity, reliability, and distinctness within the limits of distance imposed by squadron cruising, make it improbable that any device will very soon supersede it. All the principal navies of the world have adopted some such system, and the only question is as to the best apparatus, from a mechanical standpoint, for exhibiting the displays of lights needed for the different codes.

It is interesting to note, in this connection, that we are much behind other navies, in that we use five lanterns in a permanent hoist. Italy, Spain, Austria and France have adopted four lights. These, spaced in the distance formerly occupied by five or more, increase the range of visibility greatly, and with military masts and the short hoists offered by the auxiliary vessels of a fleet, such as torpedo-boats, etc., four lamps possess an enormous advantage over even five. Of course, using four lanterns implies the use either of a four-element code, or, as with the Italians, the consonants only, just as in the International code. Indeed, they have for day purposes the regular International flags, but the signal books are of course different. The principal night-signal apparatus used abroad is that on what is known as the Kaselovsky system, as improved by Lieutenant Sellner of the Austrian Navy. One of these four-lamp Sellner devices is now mounted on board the Chicago for trial as compared with the Ardois. It has, unfortunately, only twenty-seven sectors marked, and uses only the consonants. It is the type in service in the Italian Navy, and costs delivered in this country about $700. The Ardois with five lamps and sixty-four sectors is invoiced at about $1180. In point of workmanship it looks as if the Ardois were much superior, but there are excellent points in each that might well be embodied in an apparatus of home manufacture. The proposition is simply how to best and most economically mount four double (red and white) lanterns in a permanent hoist, and make certain displays of lights by means of keys. The Ardois lantern is far from satisfactory. American ingenuity can be trusted to solve the problem. An apparatus designed by Ensign F. J. Haeseler, U. S. Navy, possesses great merit, but the

field is an open one. If the Navy Department will settle the vexed question of the numerous codes we would soon have smooth sailing. There is enough data in the office of Naval Intelligence and available in the Squadron of Evolution to warrant an official inquiry and settlement, by a board of officers or otherwise, of all the points at issue. The revision of the general signal book need in no way interfere with this, although it is certainly an open question as between the use of flags similar to the International and those in the present numeral day flag code. It is generally admitted that the present method calls for too many flags in a hoist. The principal argument against any change is the great expense of devising and printing new signal books. There is, however, a further reason for going slowly in the matter. There is a growing feeling that some device like collapsing shapes will eventually supersede flags for day signals, in which case a numeral code would seem to be necessary. It will, however, be observed that this question does not enter into the one under consideration, that of night signals, for a four-element code admits of both the International (consonants) and the numeral code.

The Germans use a three-element code and a hoist of three lights. The English Admiralty in June last ordered a three-lantern Sellner apparatus for experiment. Three lanterns restricts the usefulness of the system to numeral codes only, whereas four admits of both an alphabetical and numeral code, as will be shown.

Experience in foreign services has led to the universal condemnation of the green light for general signal purposes (that is, a green transmitted light as distinguished from a chemical one, as in the Very system). Indeed, it is even so well recognized that a white light is visible in thick weather farther than a red one, that in the latest Sellner apparatus four white lights only are used. What *was* the red light in a display is now a pulsating white one, readily distinguishable from the steady white light. The pulsations are given by taking the current from a specially arranged commutator, and it is claimed that a pulsating light is visible very much farther in thick weather than even a steady white one. Dynamos and apparatus are furnished cruising torpedo-boats in some foreign services, with the fixed hoist of four lanterns. In fact, the whole question seems to have passed the experimental stage in which we find ourselves. By a simple device, in the later types of the Sellner apparatus the signal made is automatically recorded on a slip of paper, so as to check errors and preserve a record.

We have now for night signaling, both in the North and South Atlantic Squadrons, 1st, the Ardois alphabet and numeral code; 2d, the American Morse alphabet and numeral code, transmitted in one of three ways, viz., by three lights and a hand keyboard, by a torch wig-wag, or by fog whistle; 3d, two Very codes, one of three elements with brackets (the original), and a very successful and desirable experimental code of four elements. As the Coston signals have not as yet been officially suppressed, it might not be unfair to include this system and code in the list, as well possibly as the hoists of oil lamps in the general signal book. This is a somewhat chaotic condition of affairs, but the solution is absolute simplicity itself.

1st. Abolish the Coston, the oil lamps, and the original Very three-element code.

The Coston lights are from time to time sent out into service to be further experimented with. The system is a back number and should be given its quietus officially. The Very signals, as a system, are the best long-distance nautical night signals in the world, but the original code introduced the bracket in order to get a three-element code with two colors. If, however, one ball fails, as is too often the case, it is necessary to repeat the whole signal. This is not only exasperating, but is a grave defect. With the four-element code, failures do not interfere, as two minutes delay are allowed between elements. The four-element code should unquestionably be adopted in place of the original, and a further change made of using white in place of green. There is no fault to be found with the chemical green light, but as the night signal colors are now red and white, uniformity calls for the change. There is another reason which will appear later on.

2d. Retire the American Morse code, excepting for expert signalmen to use in communicating with Army stations.

3d. Drop the present Ardois code as unnecessary.

4th. Adopt the four-element Very code, for all purposes, as the numeral code.

The Very system has also come to stay, and every watch officer, watch petty officer and signalman has to know it or should be required to know t. The four-element code is as follows:

1. RRRR	2. GGGG
3. RRRG	4. GGGR
5. RRGG	6. GGRR
7. RGGG	8. GRRR
9. RGGR	0. GRRG

To use this on the Ardois or other apparatus with four lanterns, the green would show white and the red show red, but it is urged that the Very signals be changed in that respect from green to white. To use the numeral code on the fog whistle or in the ordinary wig-wag, transcribe it so that for red read *one*, and for green or white read *two*, thus:

1. 1111	2. 2222
3. 1112	4. 2221
5. 1122	6. 2211
7. 1222	8. 2111
9. 1221	0. 2112

In other words, where we now have in service four numeral codes, viz., the Morse, the Ardois, the Very three element, and the Very four element, substitute the last named for all—one for four.

5th. Adopt the Myer alphabet, dropping everything but the letters.

The service is a unit on a return to the Myer code. It was used through the war and for eighteen years subsequent. It is a four-element alphabet, and requires only four lanterns in a permanent hoist. Its elements of *one* and *two* are more distinct to the ear on a fog whistle than a dot dash system; the eye catches them more distinctly with the night flashing or winker light, and an inexperienced operator can make *one*, *two* better on a key than he can a dot, dash. It only requires one winker light to transmit the Myer, whereas the American Morse takes three.

In other words, the five propositions here submitted mean simply, *adopt what may be called the Myer-Very code for all purposes, and practically drop everything else of the kind.*

It is amazing how much this simplifies matters. The Ardois apparatus now in service can be converted without expense to the new code by pasting the Myer-Very characters over the proper sectors, and by doing away with the lowest lantern of the five. On the Philadelphia, for instance, her new masts crowd five lanterns to the point of failure, but there is full room for four. Instead of a signal box with sixty-four sectors, we would in future need one with thirty or thirty-two, and instead of five lanterns only four. This means a great saving in cost. It is proposed, with the adoption of the Myer-Very code, that signals be read in the hoist from top downwards, instead of from bottom upwards, as in the Ardois at present. This last named can be changed in five minutes to read that way.

It will be noted that there are only thirty possible combinations of the numerals *one* and *two* limited to four elements as a maximum. On the other hand there are twenty-six letters and ten numerals to be provided for in the Myer-Very, or thirty-six in all. It happens that the Very duplicates in its numerals seven of the Myer consonants, *z*, *f*, *j*, *g*, *v*, *m* and *b*; moreover, there is a still more fortunate circumstance in that the character 2212 occurs in neither. This is vital, as it comes in as the "interval" separating words and groups of numbers. The three numerals not duplicated in the Myer alphabet are 1, 3 and 8, and are available for general and code calls. The assignment is as follows:

Cornet (General call), ...	1111
Letters call, ...	1112
Numeral call, ...	2111
Interval, ...	2212

The cornet is the general call. When followed by an initial letter it calls a particular ship. The "letters" call indicates that the signals which follow are to be read as a spelled-out message. The "numeral" indicates that numerals follow. We have now in the signal book G. L. U. (geographical list use), T. D. U. (telegraphic dictionary use), S. B. U. (general signal book use), etc., and these are available for code signal calls to indicate in what book to look for the significance of the signal made. In the wig-wag, the Myer signal "numerals follow" will indicate that the signal is to be read as a numeral, or if no such signal is made, as alphabetical.

This whole scheme was, by order of the Commander-in-Chief of the Squadron of Evolution, recently submitted to a board of officers of which Captain Philip, U. S. N., was senior member, and was by that board unanimously approved. Experiments in the lines laid down are contemplated this winter. Four lanterns and thirty sectors will accomplish all that five lanterns and sixty-four sectors will, if the Myer-Very code is used. In deference, however, to the expressed fear that in restricting ourselves to thirty sectors we may be tying ourselves down for unforeseen contingencies, the writer would suggest that two or four sectors be added and a pulsating current (produced either by a commutator or an automatic make and break in these sectors) be introduced if necessary for certain unforeseen code calls or added characters. It is of very great importance that we come down to the four lanterns in a hoist instead of five.

The Myer-Very code would require the thirty sectors to be marked as follows, reading from top down:

(Note: *one* is red, and *two* white. The corresponding Ardois sectors are given to read from top down.)

		Myer-Very.		Ardois.
A	=	22	=	"Numeral"
B or o	=	2112	=	"Gen"
C	=	121	=	2
D	=	222	=	"Error"
E	=	12	=	"Final"
F or 4	=	2221	=	"Annul"
G or 6	=	2211	=	"Understand"
H	=	122	=	H
I	=	1	=	"Interval"
J or 5	=	1122	=	T
K	=	2121	=	3
L	=	221	=	"Cornet"
M or 9	=	1221	=	I
N	=	11	=	O
O	=	21	=	1
P	=	1212	=	B
Q	=	1211	=	C
R	=	211	=	9
S	=	212	=	2
T	=	2	=	o
U	=	112	=	P
V or 7	=	1222	=	L
W	=	1121	=	Q
X	=	2122	=	4
Y	=	111	=	W
Z or 2	=	2222	=	Key No. 2
Cornet or 1	=	1111	=	"tion"
Letters or 3	=	1112	=	X
Numerals or 8	=	2111	=	Blank 45
Interval	=	2212	=	——

With regard to the Very night code there are several great improvements admissible. In the first place, the change of the green to white is very important for uniformity, and moreover there is no reason why, with the Myer-Very code, we should not be able

to use the Very signals for the alphabet for long distances instead of limiting it to the numeral code only. This can be accomplished by using the green ball for the word interval and the red and white for the elements. The importance of all this is that it enables vessels not provided with electrical apparatus to use the Myer-Very code in communicating with vessels that have. With picket launches, wooden cruisers of the old type, and torpedo-boats this is a consideration. The Very pistol should be replaced in service by double-barreled breech-loading shot-guns with short barrels.

It is never out of place to urge that signalmen be made petty officers ranking with coxswains, and that the pay be increased to $30 per month; also that quartermasters be given $35, and chief quartermasters $50.

To summarize: The service at large favors a return to the Myer code, and we must eventually adopt the Very four-element code, so why not adopt the Myer-Very code and enable us to use four lanterns instead of five in a permanent hoist? All the principal foreign services are down to four, and the Myer-Very is a step in the right direction. It leaves the question of flags *vs.* shapes open for future settlement; it brings order out of chaos; it cheapens the present apparatus; it gives us an alphabet for distant night signaling; and, above all, it offers a substitute for the American Morse code, than which nothing worse can be devised.

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THE STATICS OF LAUNCHING.

By Assistant Naval Constructor William J. Baxter, U.S.N.

Launching is the operation by which a ship is transferred from the building slip into the water, and is performed by causing her to rest on a carriage, *the cradle*, which is allowed to slide along lubricated inclined planes, *the ways*, that extend from the slip into the water, until she is water-borne. She may enter the water broadside on, bow on, or stern on; the latter condition only will be investigated. In discussing the statics of launching it is assumed that the ship descends along the ways so slowly that the velocity may be neglected; the effects of the actual velocity will be considered afterwards.

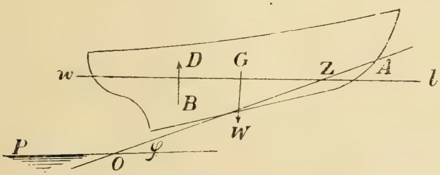


Fig. 1.

Let the ship be resting on the ways OA (Fig. 1), which are inclined at an angle ϕ, the forward end of the cradle being at A and the water-level at OP; let the water-line wl be parallel to OP. The ship will move along the ways the distance OZ before entering the water. As she continues to descend, the water-level coincides with water-lines parallel to wl, and when she has moved the distance OZ the water-level will correspond with wl. It is more convenient, however, to assume that the ship is stationary on the ways, and that the water-level has slowly risen until it is at wl; and as the inclination

of the ways is always known, with every assumed rise of water-level the corresponding descent along the ways, or the horizontal travel will be known.

The ship's weight W will act downwards through the center of gravity G at all times; but if, at any instant, the water-level is at wl there will be an upward pressure and opposite to the weight of the volume of water displaced, and this upward pressure or buoyancy D will act through the center of gravity of the displaced fluid B, the center of buoyancy. The quantity of water thus displaced is termed the ship's displacement, and is usually measured by its weight in tons; 35 cubic feet of ordinary salt water, or 36 cubic feet of fresh water, weighing one ton. As the water-level rises or falls, the volume displaced changes in shape and in quantity, causing the displacement to change in quantity and the center of buoyancy to change in position. These changes can, however, be represented graphically.

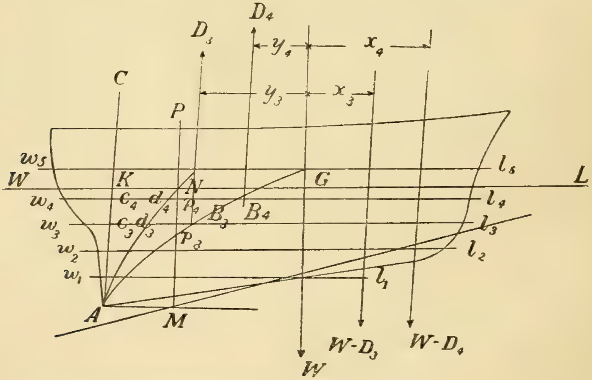


FIG. 2.

In Fig. 2, let w_1l_1, w_2l_2 . . . . w_5l_5 be a series of horizontal water-lines, and AC be a vertical through the foot of the stern-post; from this vertical set off along the water-lines to any convenient scale, the displacements up to each water-line; the curve drawn through the points thus plotted will be the *curve of displacement*. In like manner set off along each water-line the distance the center of buoyancy lies forward of the vertical AC; the curve drawn through these points is

called the *buoyancy curve*. It does not show the actual positions of the centers of buoyancy, but gives the intersections of verticals through these centers with the corresponding water-lines.

Having these curves drawn with the given water-line, the displacement and center of buoyancy are readily found for any other water-line, being its intersections with these curves.

The ship will float when the displacement equals the weight; then if AM represent W, to the scale of curve of displacement and the *weight line* MP be drawn parallel to AC, its intersection with the curve of displacement at N will be a point on the water-line cutting off a displacement equal to the ship's weight. This water-line WL is called the *flotation line*.

When the water-line has risen to w_3l_3 the ship's weight W acts downward through G, and her buoyancy D_3 acts upward through B_3. The resultant of these two parallel forces at a distance y_3 apart acting in opposite directions is $W—D_3$ represented by d_3p_3 acting parallel to them at a distance x_3 forward of G such that $x_3(W—D_3) = y_3D_3$.

$$\therefore\ x_3 = \frac{y_3D_3}{W-D_3}.$$

When the water-level is at any other water-line such as w_4l_4 there will be another displacement D_4. and the new line of buoyancy will pass through B_4 at a distance y_4 from G. The ship's weight remaining the same, there will be a new resultant $W—D_4$ whose line of action will be at a distance x_4 forward of G such that

$$x_4 = \frac{y_4D_4}{W-D_4}.$$

Since D_4 is greater than D_3, x_4 is greater than x_3.

As c_3d_3 represents D_3 and AM represents W, d_3p_3 will represent $W—D_3$; similarly, d_4p_4 will represent $W—D_4$.

This being true for any water-line, the equation is made general by writing it

$$x = \frac{yD}{W-D},$$

where y and x are respectively measured to the left and right of the vertical through G on the water-line passing through B; $W—D$ being represented by the distance from the curve of displacement to the weight-line MP.

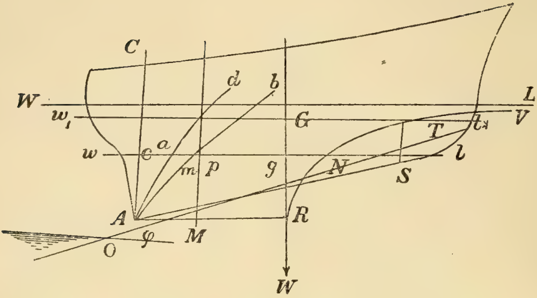


FIG. 3.

This is the equation of the *Curve of Resultants*, $R\,V$, Fig. 3, which passes through the intersections of the water-lines with the lines of action of the resultants. In this equation $x = 0$ when $D = 0$, so that the origin of the curve is at R, the intersection of the water-line passing through the lowest point of the ship, which is in most cases the foot of the stern-post, with the vertical passing through G, the center of gravity. Also when $D = W$, $x = \infty$, so that the flotation line is the asymptote of the curve of resultants, and the two will never meet. Knowing these properties, the curve of resultants is constructed in the following manner:

Draw the sheer plan of the ship, the bottom of the keel $A\,S$ having the inclination of the line of keel-blocks; then the *line of ways* $A\,T$ representing the top of the ground-ways in the proposed position both as regards height and inclination. Draw a number of water-lines spaced from 18 inches to two feet apart, and calculate for every water-line the displacement and distance of center of buoyancy forward of vertical through foot of stern-post AC, and from the values thus obtained plot the curves of displacement Aa and buoyancy Ab, and construct the weight MP, flotation WL, and gravity GR lines. The curve of resultants $R\,V$ has its origin at R, and WL is its asymptote. Any intermediate point N corresponding to a water-line wl is at once found, as $ca = D$, $ap = W - D$, $mg = y$, $AM = W$.

$$\frac{Dy}{W - D} = x = gN = \frac{mg \times ca}{ap}.$$

Through the points thus obtained the curve of resultants is drawn with its origin at R and with WL for an asymptote.

For any water-line the resultant $W—D$ is equal to pa, and its line of action is the vertical passing through the intersection of the water-line with the curve of resultants at N, or the value of the resultant can be calculated, since

$$W-D=\frac{Dy}{x}=D.\frac{mg}{gN},$$

so that we can at once determine the actual pressure on the ways and the line of action of this pressure. Conversely, knowing the line of the resultant, its value and the corresponding water-line can be found; thus if the line of action passes through N, wNl is the corresponding water-line, and pa the value of the resultant, which can also be calculated as before.

As the ship descends, the water-line rises, the resultant becomes smaller and its line of action moves forward. Let the forward poppet-lashing pass under the ship below S, then when the water-level has risen to w_1l_1 the line of action will pass through T. If it rises higher the line of action will pass forward of S, and if it sinks lower the line of action will pass aft of S. When aft of S the resultant meets the equal and opposite reaction of the ways, and the motion of the ship is not affected by it; but when the line of action is forward the reaction of the ways is not opposite, as it cannot move forward of S; the ship therefore pivots about its forward support at S, the stern lifting. The forward poppet-lashing, when using two lines of ways, or the forefoot, when launching on the keel, is called the *pivoting point.* While aft of this point, the pressure due to the resultant is distributed over the whole length of the cradle; but when the line of action passes through S or is forward of it, the whole pressure due to the resultant is concentrated at S. Since the value of the resultant decreases as the water-level rises, it follows that when the line of action passes through S this concentrated pressure is greatest. The ways, poppet-lashing, and ship must be strong enough to resist this *pivot pressure*, and its value should always be carefully ascertained.

As a practical example, take a ship whose launching weight is 1500 tons, having ways 18 inches broad and a cradle 200 feet long. The pressure in tons per square foot on the ways is evidently

$$\frac{1500}{200\times 2\times 1.5}=2.5 \text{ tons.}$$

If at the instant before pivoting, the length of cradle-support is 40 feet, and $W—D=600$ tons, the pressure per sq. ft. on the ways will be

$$\frac{600}{40\times 2\times 1.5}=5 \text{ tons.}$$

But at the instant after pivoting, when the line of action passes forward of the pivot, and the ship has begun to change trim, the whole resultant pressure will now be concentrated on not more than two poppets on each side, or two feet of the cradle; and if $W—D$ now equals 594 tons, the pressure per square foot will now be

$$\frac{594}{2 \times 1.5 \times 2} = 99 \text{ tons.}$$

In actual practice the pressure will be less than this, as it will be somewhat distributed over the forward pieces of the bilge-ways; but this will suffice to show how great the pressure may become, and how carefully the strength of poppet-lashings and poppets should be proportioned, to avoid all possibility of accident.

As this pivot pressure reacts on the ship, she must be strong enough to resist it, otherwise deformation or crushing may occur. Ships of ordinary form and scantling may be considered safe if the usual precautions are observed, since there have been many successful launches. But with ships of unusual types, especially those of very great tonnage or very light scantlings, a careful investigation should be made, and an ample factor of safety provided for, internal shoring being used when necessary.

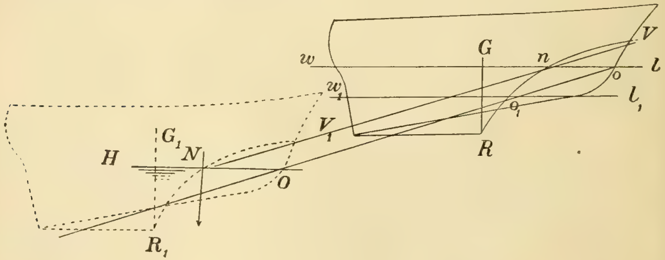


FIG. 4.

Suppose the ship to descend along the ways with inappreciable velocity and gradually enter water having a constant known level. In Fig. 4, let OH be the water-level and RV the curve of resultants, and wl be any water-line; wl will coincide with OH when the ship has moved the distance Oo. If the ship had remained stationary and the water had risen to the level wl, the line of action of the resultant would pass through n, the intersection of the curve with the water-line, at a distance on from the line of ways; when the ship has

descended the ways and occupies the position shown in dotted lines, the resultant pressure acts through N, ON being equal to on. The line of action of the resultant pressure will therefore pass at a distance from O, equal to the distance from the intersection of the curve of resultants with the water-line, to the intersection of this water-line with the line of ways. The intersection of the normal or average water-level with the line of ways, projected at O, is called the *shore line.*

For the water-line w_1l_1 which intersects the curve at the same point where the latter meets the line of ways, the line of action passes through the shore-line at O; and for any water-line below w_1l_1 the resultant will pass inside the shore line. It therefore follows that, as the ship descends along the ways and enters the water, the resultant downward pressure acts inside of the shore-line as long as the water-level is at a water-line whose intersection with the curve of resultants is below the line of ways, and the resultant acts outside the shore-line when this intersection is above the line of ways.

The actual position of the line of application of the resultant downward pressure during the ship's descent along the ways, when any given water-line coincides with the water-level, is found by drawing the *distance line* Nn parallel to the line of ways through the intersection of the water-line and the curve at n; ON is evidently equal to on, and N is therefore the point required.

This resultant pressure must meet an equal and an opposing force in order that the ship may remain in equilibrium. This opposing force is the reaction of the ways; they must evidently be long enough to produce this reaction for all positions of the ship between the original one of rest and the final one of flotation.

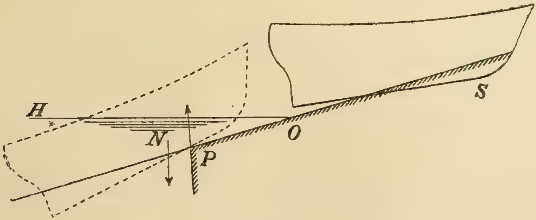


FIG. 5.

In her descent along the ways and before pivoting begins, let the ship occupy the position shown in full lines in Fig. 5, the downward

resultant pressure acting through N, OH being the water-level, S being the pivoting point, and P the outer end of the ways. There being no equal and opposing force, the resultant causes the ship's stern to descend, taking the position shown in dotted lines. As she continues to move onward she scrapes against the end of the ways, until the displacement of the after-body increases so that she begins to raise her stern, and finally her fore-body strikes on the ways again. This *stumbling* occurs often; it is dangerous and frequently results in serious damage to the ship; in shallow water the stern may strike the bottom and the launch be a vexatious and costly failure.

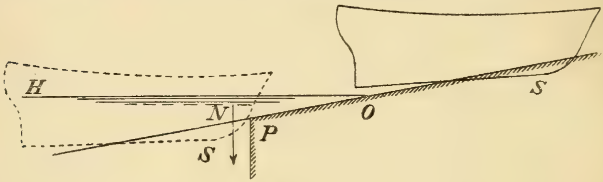


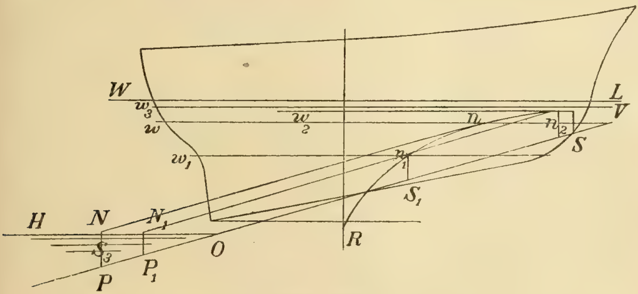
FIG. 6.

With a ship whose pivoting point S, Fig. 6, is some distance aft of the forefoot another danger may be feared if the ways are so short that the resultant passing through N acts beyond P before the ship has floated. The ship then takes the position shown by the dotted lines, the forefoot falls, striking or scraping the foot of the ways. Although dangerous, this *tripping* seldom occurs.

These phenomena, although they are modified by the effects of the ship's velocity, show the absolute necessity of having the ways of such ample length that the line of action of the resultant downward pressure shall always be inside the end of the ways, and that the pivot shall always be supported until the ship floats. When the curve of resultants is below the line of ways, it has been shown that the line of action of the resultant lies inside the shore-line and there is no danger when the ways extend into the water; but when the curve is above the line of ways the resultant moves outside the shore-line, and stumbling or tripping will occur if sufficient length be not provided of *underwater* ways, the length of ways extending from the normal shore-line measured along the line of the water-level.

Let $R V$ be a curve of resultants in Fig. 7, OH the water-level, PS the line of ways and S the pivoting point. For any water-line

such as w_1l_1, the resultant acts through N_1; as the ship descends the resultant recedes from the shore-line until a water-line wl is reached, such that the corresponding distance-line is tangent to the curve. As the ship continues to descend the resultant now advances towards the shore-line, passing a water-line such as w_2l_2 whose distance-line corresponds with that of w_1l_1 until water-line w_3l_3 is reached and the ship begins to pivot, the resultant then acting inside of N, and it continues to advance towards the shore-line until the ship floats. If the underwater ways extend as far as P, the resultant downward pressure meets the equal and opposite reaction of the ways and the ship is always in equilibrium from start to flotation. But if the underwater ways extend only to P_1 the ship would stumble as soon as water-line w_1l_1 was passed, and would strike the ways again when wl was reached. Tripping, however, would never occur.



FIGS. 7 AND 8.

Let the pivoting point be at S_1, Fig. 7; the resultant recedes from the shore-line until wl is reached and then returns towards it. Pivoting begins when water-line w_1l_1 is reached, and if the underwater ways extend only to P_1 the ship will begin to trip as soon as she descends deeper into the water and will so continue until flotation, as the resultant rapidly moves forward and the pivoting point is unsupported thereafter. If the underwater ways did not extend to P_1, stumbling would first occur and then tripping.

In general, when the distance-line corresponding to a given length of ways is above a tangent to the curve of resultants of a given ship, neither stumbling nor tripping will occur, and the ship will be well supported from start to flotation; but when the distance-line intersects the curve, stumbling occurs when the pivoting point

is forward of the second intersection; tripping occurs when the pivoting point is at the first intersection; stumbling and tripping both occur when the pivoting point is forward of the first intersection, but between it and the second.

To prevent stumbling or tripping and to have the ship well supported from start to finish, the length of underwater ways must not be less than that given by the distance-line tangent to the curve of resultants.

The depth of water above the end of the underwater ways is known as:

Depth of water on end of ways = length under waterways $\times$ tangent of angle of inclination of ways.

Or, depth of water on end of ways = length of under waterways $\times$ descent per foot $\times \frac{1}{12}$.

Thus with underwater ways extending 48 feet beyond the shoreline and having an inclination of $\frac{3}{4}$ inch per foot,

$$\text{depth of water} = \frac{48 \times \frac{3}{4}}{12} = 3 \text{ feet.}$$

The curve of resultants can be accurately drawn, and the pivot pressure and length of ways required can be accurately determined when the following are accurately known:

1. The ship's displacement curve.
2. The ship's buoyancy curve.
3. The angle of inclination of the ways.
4. The position of the ship on the ways.
5. The position of the pivot.
6. The weight of the ship.
7. The position of the center of gravity.
8. The water-level at the moment of launching.

The first and second can at once be determined from the ship's lines and the known inclination of the keel-blocks; the third will be decided by the depth and extent of water available and other practical considerations; the fourth is known; and the fifth decided by the ship's form; all being accurately known months before the ship is launched.

But with the remaining three there is more or less uncertainty at the time the launching calculations are made. The ship's weight is only known approximately, even where an accurate record is kept of all the weights placed on board, as the amount added between the time of the calculation and the time of launching cannot usually

be accurately foreseen, since circumstances frequently arise necessitating the launch being advanced or postponed from the time originally set. Still less is it possible to foresee the exact position of the ship's center of gravity.

Nor can the water-level at the moment of launching be accurately known, especially in tidal waters. Though the height and time of mean high water are known, during the time lost by unforeseen delays the water-level will change; and in all waters, freshets and strong winds may change the level.

The variation of these three conditions modifies the curve of resultants, since it is plotted from the equation,

$$x = \frac{Dy}{W-D},$$

in which W varies with the weight and y with the position of the center of gravity. The pivot pressure and the length of ways outside the shore-line vary with the curve; and the total length of ways required will vary with the water-level although the curve remain unchanged, as the length of the underwater ways must remain constant with a given curve. All probable variations of these three conditions should therefore be considered in making the launching calculations.

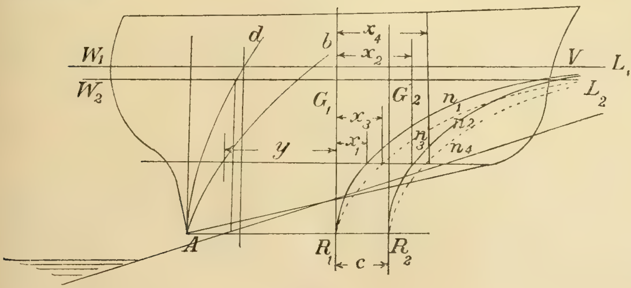


FIG. 9.

From knowledge of the design and type of ship, the probable receipt of materials and rate of progress of the work, W_1 and W_2, the respective maximum and minimum values of the ship's weight, may be assumed. Similarly assume that a and b are the respective distances abaft the midship section, of the ship's center of gravity,

giving them negative values when the center of gravity is forward. The curve of displacement Ad and the buoyancy Ab, Fig. 9, remain unchanged, but W_1L_1 and W_2L_2 will be the two flotation-lines corresponding to W_1 and W_2 respectively. Let G_1 and G_2 be the two limiting positions of the center of gravity at a distance c apart, and G_1R_1, G_2R_2 the two verticals, and suppose each weight to be concentrated first at G_1 and then at G_2.

With the weight W_1 and the center of gravity at G_1 the origin of the curve is at R_1, and W_1L_1 is the asymptote, and any point on the curve corresponding to a given water-line is found by the equation,

$$x_1 = \frac{Dy}{W_1 - D}, \tag{1}$$

giving the curve $R_1n_1V_1$; W_1L_1 being the asymptote.

When the same weight W_1 has its center of gravity at G_2 the equation becomes

$$x_2 = \frac{D(y+c)}{W_1 - D}, \tag{2}$$

giving the curve $R_2n_2V_2$; W_1L_1 being again the asymptote.

With the weight W_2 having its center of gravity at G_1, the equation becomes

$$x_3 = \frac{Dy}{W_2 - D}, \tag{3}$$

giving the curve $R_1n_3V_3$; with W_2L_2 for an asymptote.

But when this weight W_2 has its center of gravity at G_2 the equation becomes

$$x_4 = \frac{D(y+c)}{W_2 - D}, \tag{4}$$

giving the curve $R_2n_4V_4$; also having W_2L_2 for its asymptote.

The four curves of resultants given by these four equations give all the necessary information required to pre-arrange all the details of the launch,

$$x_1 = \frac{Dy}{W_1 - D}, \tag{1}$$

$$x_3 = \frac{Dy}{W_2 - D}. \tag{3}$$

Comparing the curves of equations (1) and (3), it is seen in Fig. 10 that D and y are the same in each; but as W_1 is greater than W_2, x_1 is always less than x_3, showing that for any water-line the ordinate

of (1) measured from the vertical G_1R_1 is less than the ordinate of (3) on the same water-line. As this is true for any water-line, curve (1) is always nearer the vertical through G_1 than curve (3), and the curves never intersect. Also as o_1n_1 is always greater than o_2n_2 and n_1p_1 greater than n_2p_2 for any water-line, the ordinate of (1) measured from the line of ways is greater than the ordinate of (3) measured from this line. This being true of all water-lines, the tangent distance line to curve (1) will be at a greater distance from the line of ways than the tangent to curve (3). But as the length of underwater ways increases with the horizontal distance of the tangent distance line from the line of ways, the length of ways required by curve (1) is greater than that required by curve (3).

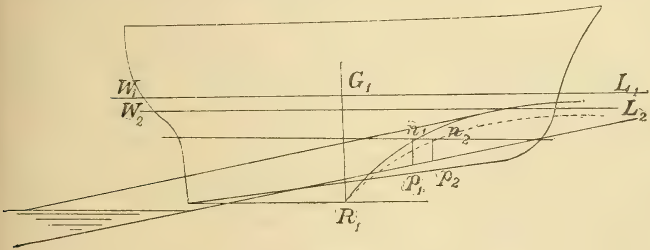


FIG. 10.

Comparing the curves of equations (2) and (4),

$$x_2 = \frac{D(y+c)}{W_1 - D}, \tag{2}$$

$$x_4 = \frac{D(y+c)}{W_2 - D}, \tag{4}$$

D and $(y+c)$ are the same in each, but as W_1 is greater than W_2, x_2 is always less than x_4. Curve (2) will therefore always be above curve (4) and will require a greater length of ways.

Hence, for any given position of the ship's center of gravity, the length of underwater ways required will increase when the ship's weight is increased.

Comparing the curves of equations (1) and (2),

$$x_1 = \frac{Dy}{W_1 - D}, \tag{1}$$

$$x_2 = \frac{D(y+c)}{W_1 - D}, \tag{2}$$

D and W_1 are the same in each, but as $(y + c)$ is greater than y, x_2 is always greater than x_1. Curve (1) will therefore always be above curve (2) and will require longer ways. For similar reasons, longer ways will be needed for curve (3) than for curve (4).

Hence, for any given weight of ship, the length of underwater ways required will increase when the ship's center of gravity is moved aft.

Comparing the curves of equations (2) and (3),

$$x_2 = \frac{D(y + c)}{W_1 - D}, \tag{2}$$

$$x_3 = \frac{Dy}{W_2 - D}. \tag{3}$$

The asymptote W_1L_1 of (2) is above the asymptote W_2L_2 of (3); and as the origin of (2) is forward of that of (3), the two curves intersect. The point of intersection cannot be determined directly from the equations, and its relative position varies with different ships; the same is true of the relative convexity of the two curves. In most ships, however, the tangent distance line of (3) is above that of (2). A less weight of ship with its center of gravity farther aft usually requires a greater length of underwater ways than a greater weight whose center of gravity is farther forward.

Comparing the curves of equations (1) and (4),

$$x_1 = \frac{Dy}{W_1 - D}, \tag{1}$$

$$x_4 = \frac{D(y + c)}{W_2 - D}. \tag{4}$$

The asymptote W_1L_1 of (1) is above the asymptote W_2L_2 of (4); but as the origin of (1) is aft of that of (2), and $W_1 - D$ is always greater than $W_2 - D$, the curves never intersect and (1) is always above (3). A greater weight of ship with its center of gravity farther aft always requires a greater length of ways.

The water-level has been supposed constant, but as it may change by the influence of tides, seasons, freshets or droughts, the effects of this change must be considered. In Fig. 11, let OH be the usual water-level, O being the shore-line, we have seen that the length of underwater ways required is $ON = on$, the distance from the point of tangency n of a tangent distance line to the line of ways measured on the water-line wl passing through this point. If the water-line be

at O_1N_1, the outer end of the ways must be below N_1 where $O_1N_1 = on$; or if the level be at O_2N_2, the outer end of the ways must be below N_2 where $O_2N_2 = on$. So that if the water-level falls, the *total* length of ways is increased the distance $N_1K_1 = \dfrac{O_1K}{\tan\varphi}$, and if the level rises, the length is decreased the distance $O_1K_1 = \dfrac{O_1K}{\tan\varphi}$. Hence, as the water-level falls or rises above the normal level, the total length of ways or the length of ways beyond the normal shore-line is increased or diminished a distance equal to the amount of this fall or rise divided by the tangent of the angle of inclination of the ways. It should be observed that the *length of ways underwater* is the same in each case, as nN is parallel to oO, and O_2N_2, OH, O_1N_1 are parallel to one another, so that $O_2N_2 = ON = O_1N_1$. But as the length of *underwater ways* is measured from the assumed average or normal shore-line at O, this length is variable, and consequently the total length of ways varies with the position of the actual water-level.

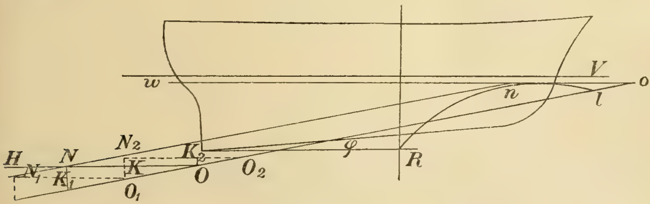


FIG. 11.

In tidal waters the shore-line assumed as normal is that of mean high tide, and the probable change of level in one hour is known. In other waters the probable level depends greatly upon the time of year. Suppose the level in either case to vary only six inches, then if the ways have an inclination of three-fourths of an inch to the foot,

$$\tan\varphi = \frac{\frac{3}{4}}{12} = \frac{1}{16}.$$

The change in length required of underwater ways is

$$\frac{6}{12} \times 16 = 8 \text{ feet.}$$

A slight change of level therefore requires a greatly increased change of total length of ways. If the level rises, this length is greater than necessary; but if it falls, the length is less than is necessary and

stumbling or tripping may occur. To ensure safety, therefore, the length of underwater ways should always be increased a distance equal to

$$\frac{\text{probable fall of water-level below that assumed}}{\text{tangent of the angle of inclination of ways}}$$

as a factor of safety. In tidal waters this probable fall should be that which would occur during the first hour after high water.

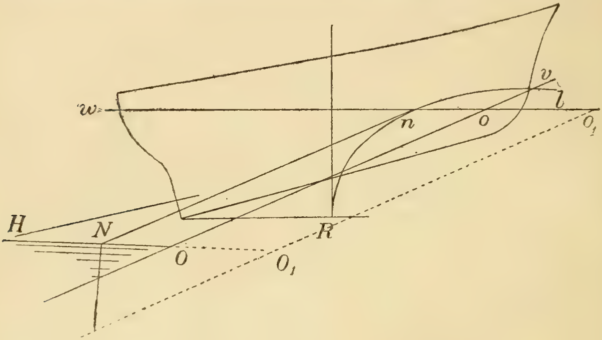


FIG. 12.

The distance of the line of ways above or below any given point on the ship, such as the foot of the sternpost, is determined by practical considerations. In Fig. 12, let the water-level be at OH, the line of ways assumed for calculation at Oo, with the shore-line at O, and let o_1O_1 be any other possible position of the line of ways. If Nn be the tangent distance line, the end of ways is determined by the vertical through N, and its position depends only on the curve and water-level.

The length of underwater ways is therefore entirely independent of the position of the ways, which may be adjusted as is found to be most advantageous.

Cost, convenience, and obstruction of the water-front must often be considered in determining the most advantageous length of underwater ways; and when possible, ways already constructed should be used. It has been shown that the length of underwater ways necessary to ensure safe launching varies with the ship's weight, the position of her center of gravity and the change of water-level.

With any given limit of length of ways, the first and second of these varying conditions should be so controlled that there will be perfect security even though the water be at its lowest probable level. The applications of the four curves of resultants can be arranged graphically so as to readily supply this information.

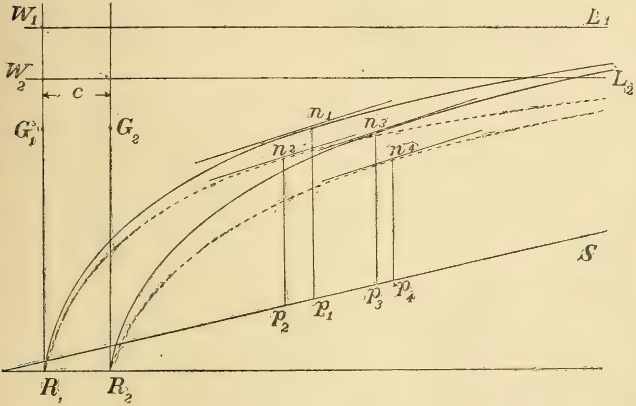


FIG. 13.

In Fig. 13, let G_1 and G_2 be the two centers of gravity at a distance c apart, then with the two assumed weights of the ship we shall have the four curves, portions of which are shown. Drawing tangent distance lines to these curves, the vertical distances between the points of tangency and the line of ways, n_1p_1, n_2p_2, n_3p_3, and n_4p_4 will represent the depths of water necessary over the end of the ways; the length of underwater ways being the depth divided by the tangent of the angle of inclination of the ways. In Fig. 14, let AB represent 8 feet, the distance c between G_1 and G_2, the two probable positions of the center of gravity, and make AN_1 equal to the length of underwater ways required by the curve R_1n_1, and to the same scale, make AN_2, BN_3, BN_4 equal to the lengths required by the corresponding curves. With ships of the usual form as commonly constructed, and with the usual launching weights, the length of underwater ways required will decrease at a nearly uniform rate as the center of gravity moves forward the distance probable in practice; hence the decrease in length of ways for any intermediate position as at E, 4

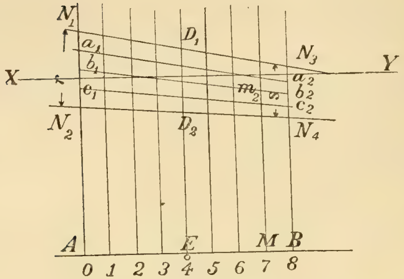


FIG. 14.

feet forward of G_1 when the ship's weight is W_1, is represented by the distance ED_1; similarly, when her weight is W_2 the length is represented by ED_2. Also, with ships of the usual form, as commonly constructed, the length of underwater ways increases at an approximately uniform rate, as the ship's weight increases, when this increase does not exceed one-tenth of the total weight; and if $W_1 - W_2 = w$ be represented by $N_1N_2 = r$ equal subdivisions, $\frac{w}{r}$ will represent the increased lengths required for these equal increasing weights. Thus if $W_1 - W_2$ equal 100 tons, and N_1N_2 be divided into four equal parts, Ab_1 will represent the length required for a weight of $W_2 + 50$ tons, when the center of gravity is at G_1. Similarly, when this center is at G_2 the length required for $W_2 + 50$ tons is represented by Bb_2. If the corresponding points of division are joined by the *meta lines* $a_1a_2 \ldots c_1c_2$ both variations are represented. Thus a point m_2 on the line b_1b_2 gives a length m_2M, corresponding to a weight $W_2 + 50$ tons with its center of gravity at a distance 7 feet forward of G_1.

To the same scale of lengths, and parallel to AB draw XY representing the maximum length of underwater ways permissible beyond the lowest probable shore-line. This line intersects some or all of the meta lines, and shows the variations of weight and center of gravity which can be safely allowed with the given length of ways.

These variations can be represented by a *distance curve* RS in Fig. 15, having the distances the center of gravity moves forward for abscissae, and for ordinates the increase of weight, to convenient scales. It is quickly plotted, as R and S are given by the intersec-

tion of XY with AN_1 and BN_3, and the other points by the intersections of XY with the respective meta lines. It is usually more convenient to make the scale of increased displacement of the distance curve some multiple of that used for the meta lines, but using the same scale of abscissae and combining them in the *distance diagram*, Fig. 16. The distance curve shows more clearly the safe variations of launching weight and position of center of gravity.

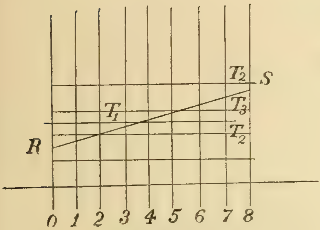


FIG. 15.

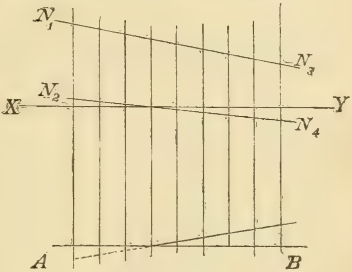


FIG. 16.

It will also indicate the necessary alterations which may be made just before the launch to ensure safety. Thus let $W_2 = 900$ tons; the day before the launch the ship's weight is found to be 960 tons, a rough calculation showing the center of gravity is 2 feet forward of G_1. This gives the spot T_1 above the curve showing that the ways are too short; the launch is unsafe. If the center of gravity can be moved forward 5 feet to T_2 there will be a safe launch. To do this by moving weights already on board would be impracticable, but when the center is at T_2, 50 more tons may be added with safety. To move the center of gravity forward 5 feet, these 50 tons must be placed at a distance S forward of G_1, and taking moments about G_1,

$$S = \frac{(960 + 50) \times 7}{50} = 141.4 \text{ feet.}$$

Thus by adding 50 tons of ballast 141.4 feet forward of G_1, the ship can be launched with safety.

It should be borne in mind, however, that the center of gravity must not be changed by adding a greater weight of ballast than 50 tons at a less distance from G_1, as in that case the increased weight would be greater than could be safely launched with the given ways,

as they would be too short. Thus if 60 tons were placed 118 feet forward of G_1, the center of gravity would still be 7 feet forward of G_1, but the total weight would now be 1020 tons and the corresponding spot would now be at T_3, above the curve, and the launch would be unsafe; but ballast less than 50 tons can be added at a greater distance than 141.4 such that the center of gravity is still 7 feet forward of G_1, as the corresponding spot will then be below the curve.

There are three types of distance curves: First, where XY does not intersect the limiting meta lines N_1N_3 and N_2N_4, as in Fig. 14. The distance curve is continuous and similar to that of Fig. 15, and the launch will be safe for all weights less than $W_2 + x^{\frac{w}{n}}$ at the after assumed position of the center of gravity; and for the forward position, will be safe for all weights less than $W_2 + y^{\frac{w}{n}}$.

Second, when XY intersects the lower water-line, as in Fig. 16, the distance curve cannot be accurately plotted abaft the intersection, as shown by the dotted line, and the launch will not be safe for a weight of W_2 unless the center of gravity is forward of the intersection. In this case great care must be taken.

Third, when XY intersects the upper meta line, as in Fig. 17, the distance curve cannot be accurately plotted forward of the intersection, as shown by the dotted line, and the launch will be safe for all weights greater than $W_2 + x^{\frac{w}{n}}$, a very unsafe launch.

Fourth, when XY intersects both limiting meta lines, as in Fig. 18, in this case the launch may be dangerous or very safe, depending on the position of the center of gravity, and great care must be taken.

The length necessary for the underwater ways may be reduced in another manner. In Fig. 19, let the curves of displacement and buoyancy give the curve of resultants $R V_1$ by the equation

$$x_1 = \frac{D_1 y_1}{W - D_1}.$$

Suppose the volume of the after-body of the ship to be increased without increasing her weight; the curves of displacement and buoyancy will then be represented by the dotted lines giving the dotted curve of resultants $R V_2$ from the equation,

$$x_2 = \frac{D_2 y_2}{W - D_2}.$$

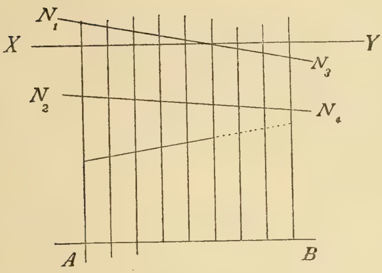


FIG. 17.

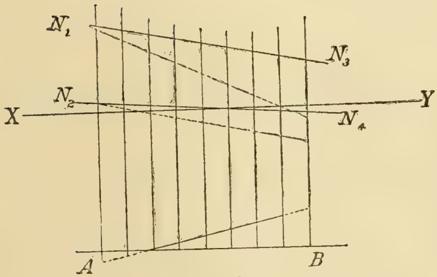


FIG. 18.

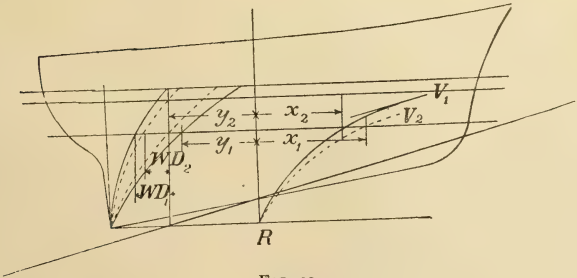


FIG. 19.

Since D_2 and y_2 are respectively greater than D_1 and y_1, $W - D_2$ is less than $W - D_1$; therefore x_2 is greater than x_1, and the curve $R V_2$ will be below the curve $R V_1$; hence the length of ways required by the curve $R V_2$ will be less than the length required by the curve $R V_1$.

In practice, increase of volume without increase of weight cannot be obtained; but by securing camels, empty barrels, or cork under the counter, the volume is increased with a minimum amount of additional weight.

This method is not practicable with large vessels. But as the pivot pressure is also generally reduced, it is particularly adapted to small vessels of very light scantling, especially when they are launched after the machinery has been placed on board.

The pivot pressure can be determined by direct calculation when desired.

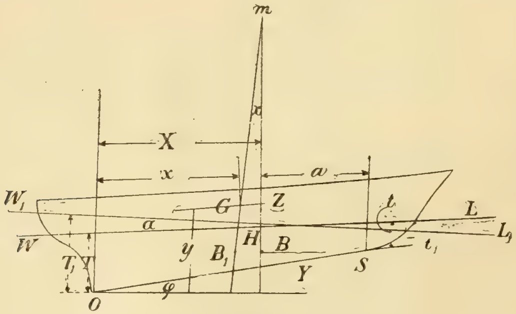


FIG. 20.

The launching trim is first found. From the displacement curve the mean draught t_0 corresponding to the given weight W is laid off on the sheer plan, the water-line WL is drawn, and the positions of the longitudinal metacenter m and the center of buoyancy B plotted. Let G, Fig. 20, be the center of gravity, its coördinates with respect to the after-perpendicular and the base-line are x and y; and the coördinates of the normal center of buoyancy B are X and Y. In order that the ship may be in equilibrium, the actual center of buoyancy must be some point B_1 on the line passing through m and G; and the actual water-line W_1L_1, after launching, must be perpendicular to mG, intersecting it at its center of gravity, since the angle of inclination a is small.

This angle is at once found as

$$\sin \alpha = \frac{X - x}{Y + Bm - y};$$

also, since α is small, the change of inclination of the keel is very approximately equal to the inclination of the water-lines. The draughts forward and aft are found in the usual manner.

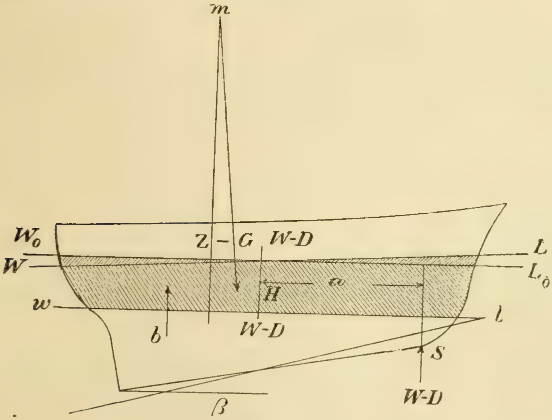


FIG. 21.

Let β, Fig. 21, be the inclination of the keel-blocks, and S the pivoting point. If the water-level be at wl when pivoting begins the ship will be in equilibrium under the forces W the ship's weight acting downward through G, the buoyancy D acting upward through b, and the resultant reaction $W - D$ acting upward through S. Let W_0L_0 be a water-line parallel to wl cutting off a displacement equal to W, and let WL be the actual water-line of the ship when she is floating after being launched. The weight of the volume of displacement of the zone between wl and W_0L_0 is evidently $W - D$, as is that of the zone between wl and WL; WL and W_0L_0 intersect at their center of gravity, as their angle of inclination ρ is small, and the centers of volume of the two zones approximately coincide at H.

Suppose two equal and opposite forces $W - D$ are applied at H, the ship will still be in equilibrium. The force $W - D$ acting upwards through H is equal to the displacement of the zone, it is

the buoyancy of the zone; so that as the sum of the upward forces is $(W - D) + D = W$, the weight and buoyancy being equal, the ship will float.

The force $W - D$ acting downward through H, being equal and opposite to the force $W - D$ acting upward through S, a couple, whose moment is $(W - D)a$, is found which would cause the vessel to rotate were it not for the moment of longitudinal stability,

$$W . GZ = W . Gm . \sin \rho,$$

acting in the contrary direction.

The ship will therefore be in equilibrium when these moments are equal.

$$W . Gm . \sin \rho = (W - D)a,$$

$$\therefore \ W - D = W . \frac{\sin \rho . Gm}{a}.$$

In practice a sufficiently accurate approximation may be made by assuming H, Fig. 20, to be on the vertical through B.

Hence with the sheer plan of the ship, the positions of G, B, and S being plotted, and the values being known of W, Gm, and the inclination of the keel-blocks, the amount of pivot pressure is found by direct calculation.

This will be especially useful when it is desired to ascertain whether a slip has sufficient strength to permit the launching of a large and heavy ship; and whether the ship is of such scantlings as will prevent deformation due to the excessive concentrated stresses during the pivoting period of the launch.

It will be observed that the pivot pressure increases as $\sin \rho$ increases; the greater the difference between the inclination of the keel-blocks and the inclination of the keel after launching, the greater is the pressure. It is therefore advisable to have this difference as small as practical considerations will permit.

A ship with any drag launched bow on will have a much greater difference than when launched stern on, the pivot pressure will therefore be greater in the former case, and for this reason ships are usually launched stern on.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH,

DECEMBER, 1891.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XXIII.

The Fifteenth Annual Report of H. M. Inspectors of Explosives, being for the year 1890, shows that though the rigid system of inspection and supervision of explosives factories and magazines, for which this corps is famous, has been maintained, it has not retarded the growth of this important industry, for during the past five years the number of factories in operation has increased from 108 to 123, while the number of persons employed has increased from 7484 to 9820. Notwithstanding this increase in production, the number of accidents occurring during the manufacture and use or abuse of explosives was 132, resulting in 44 killed and 85 wounded, while the average number of accidents for the past ten years was 137.8, resulting, on the average, in 41.4 killed and 102.6 wounded.

No statistics regarding production are given in these reports. This is very much to be regretted, as they would prove a most valuable criterion by which to measure the value and operation of the Explosives Act. Statistics are, however, given for importations, from which it appears that there was an extraordinary decrease in the amount of dynamite imported in 1890, it being but 371,650 pounds, as against an average yearly importation of 1,000,000 pounds for the past eight years. Part of this was accounted for by the increase in the amount of the gelatine explosives, yet the total of

*As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

all nitroglycerine explosives imported was less than for 1889 by over 400,000 pounds. 38,000 pounds of bellite, 9700 pounds of fulminate, and 10,950,000 detonators were also imported.

Dr. Dupre's report shows that in 1890, for the first time, the number of samples of gelatinized preparations examined exceeded those of dynamite, and points out that this increased use is due to these bodies being practically unaffected by water, and capable of being graduated in strength with greater readiness than obtains for dynamite, while in addition their plastic nature renders them more easy of use in bore-holes. These explosives are not free, however, from dangers of their own; dangers which manufacturers have not, as yet, completely overcome. The chief of these is their liability to exude. There is also a greater difficulty in insuring absolute stability under the most trying conditions of temperature and storage. Since the establishment of the manufacture of dynamite on a large scale, no authentic case of its spontaneous ignition is on record; whereas there are several such in regard to gelatinized preparations.

The consumption of dynamite is also being affected by the introduction of ammonite, bellite, roburite, securite, etc., whose greater insensitiveness to percussion and friction gives the advantage of somewhat greater safety in manufacture and use.

The different results obtained by different analysts in applying the "heat test" to blasting gelatine and its class has led to a precise description of the French chalk to be used.

For the assistance of inventors who desire to have explosives examined, a memorandum giving the necessary steps to be taken is printed in this report.

The chapter on accidents by fire or explosion, which is a characteristic and important feature of these most valuable reports, occupies some thirty-seven pages, and as usual includes a summary review of the accidents reported from abroad, as well as those occurring at home. It is noted that in the explosion of 80 tons of gunpowder at the Dupont works, October 7, 1890, a larger quantity was involved than in any previous accidental gunpowder explosion. The accidental explosion next in magnitude was that of Erith in 1864, when 57½ tons of powder exploded. The Louisiana, which was intentionally blown up before Fort Fisher in 1864, contained 200 tons of gunpowder. The author, in commenting on this, is misled by our complicated geographical nomenclature.

Extracts from this record of accidents and of that of experiments will be found later on.

Lt. Willoughby Walke, Second Artillery U. S. A., gives in *Jour. Am. Chem. Soc.* **12**, 256–274; 1890, the results of his "Determination of the Strength of Various High Explosives" by the use of the Quinan pressure gauge,* in which he employed nitroglycerine made by the Naval Torpedo Station method and carefully stored until it was thoroughly "clear," as the standard. This period of rest of several months was found necessary, as the strength of the explosive varied from day to day until it had "cleared," after which it remained constant. The results obtained were as follows:

Name of Explosive.	Diminution in Height of Cylinder in Inches.	Order of Strength.
1. Explosive gelatine made from nitroglycerine after the Vonges process	0.585	106.17
2. Hellhoffite	0.585	106.17
3. Nitroglycerine (made Nov. 19, 1889, tested Jan. 6, 1890)	0.551	100.00
4. Nobel's smokeless powder	0.509	92.38
5. Nitroglycerine (made Jan. 29, 1890, tested on same day, U. S. N. Torpedo Station process)	0.509	92.38
6. Explosive gelatine (made from nitroglycerine No. 5),	0.490	88.93
7. Gun-cotton (U. S. N. Torpedo Station, 1889)	0.458	83.12
8. Gun-cotton (Stowmarket, 1885)	0.458	83.12
9. Nitroglycerine (made according to the French process and tested on the same day)	0.451	81.85
10. Gun-cotton (made in Artillery School Laboratory),	0.448	81.31
11. Dynamite No. 1	0.448	81.31
12. Dynamite, de Trauzl	0.437	79.31
13. Emmensite	0.429	77.86
14. Amide powder	0.385	69.87
15. Oxonite (picric acid fused before being added)	0.383	69.51
16. Tonite	0.376	68.24
17. Bellite	0.362	65.70
18. Oxonite (picric acid not fused)	0.354	64.24
19. Rack-a-rock	0.340	61.71
20. Atlas powder	0.333	60.43
21. Ammonia dynamite	0.332	60.25
22. Volney's powder No. 1	0.322	58.44
23. " " 2	0.294	53.18
24. Melinite	0.280	50.82
25. Silver fulminate	0.277	50.27
26. Mercury fulminate	0.275	49.91
27. Mortar powder, Dupont	0.155	28.13

* Proc. Nav. Inst. 8, 663; 1882.

U. S. Letters Patent No. 455,217, June 30, 1891, have been granted Carl Lamm for an invention, the object of which is to provide an explosive less dangerous than nitroglycerine in its manufacture, transportation, and use.

He describes this explosive as being in the nature of a compound consisting of a nitrate (such as nitrate of ammonia, of potassa, of soda, or of baryta) and dinitro-benzine, or dinitro-benzol mixed in such proportions that when exploded the hydrogen of the dinitro-benzine or dinitro-benzol burns and forms water, and the carbon of the same material forms carbonic acid at the expense of the oxygen contained in the nitrate conjointly with the oxygen contained in the dinitro-benzine. He has also had in view the protection of the nitrates from the influence of moisture, and for this reason the dinitro-benzine or dinitro-benzol, which is a solid, is pulverized, as is also the solid nitrate, and both are then mixed and heated by steam in suitable molds to 212° F., which causes the dinitro-benzine or dinitro-benzol to melt between 176° and 212° F., and to completely envelope the particles of saltpeter or other nitrate used. The mass solidifies in cooling, and is molded into cartridges or bodies of any suitable shape, or it may be pulverized or granulated.

He has found the following proportions of ingredients to give the best results: dinitro-benzine, one part, and nitrate of ammonia, at least 1.9 parts; dinitro-benzine, one part, and nitrate of potassa, 0.96 part; dinitro-benzine, one part, and nitrate of baryta, 1.24 parts; dinitro-benzine, one part, and nitrate of soda, 0.81 part.

The above proportions are so selected as to yield or form carbonic oxide and water on explosion.

If the proportion of saltpeter or other nitrate be increased about three times, carbonic acid and water will be formed, which gives the best results for mining purposes.

He states the advantages of this explosive as: Impossibility of explosion from shock or blow; non-ignition by fire; possession of more power than other high explosives; non-congelation at a low temperature; pulverization without danger previous to use; safety in transportation and storage; advantageous use in coal mines in place of gunpowder, and requiring from a fourth to a fifth only of the quantity.

He claims: 1. An explosive compound composed of a nitrate salt and dinitro-benzine or dinitro-benzol substantially as and for the purpose specified; 2. an explosive compound composed of nitrate

of ammonia and dinitro-benzine or dinitro-benzol, substantially as described.

In his improvements relating to the manufacture of nitrocellulose or pyroxyline, English Patent 20,978, Dec. 23, 1890, G. M. Mowbray uses, as raw material, cotton rags, cotton lint from cotton-seed hulls, and other materials, instead of fine pure unsized cotton tissue paper, and first steeps it in a bath of a salt, preferably a nitrate, and then passes it between rollers and slowly dries it. The salt crystallizes in the cells of the fiber, and this action opens up the cells so that when the material is subsequently immersed in the acid bath, nitration takes place more rapidly and is effected at less cost than by the present process. It is pointed out that, although a nitrate is preferred, "any salt crystallized, or even water crystallized by freezing, in the cells of the fibrous cellulose, facilitates nitration by rendering the inner walls of the cellular tissue more readily accessible to the acids of the immersion bath."—*Jour. Soc. Chem. Ind.* **10**, 271; 1891.

U. S. Letters Patent No. 454,281, June 16, 1891, have been granted Hiram S. Maxim for "Method of Making Gun-Cotton." He claims to render available, by this method, all the valuable properties of the acids, and to be able to use such acids until they have become entirely spent, or until they have parted with nearly all their constituents that go to effect the nitration of the cotton. The method involves the employment of a series of six receptacles or vats filled with a mixture of the strongest acids procurable. These vats are arranged on a table or platform, mounted so as to turn about a central pivot or shaft.

In using this apparatus a given quantity of cotton is immersed, say, in vat 1. It is then removed and freed from the excess of acid by any suitable means, such as a centrifugal separator. The acid separated from the cotton is returned to the vat from which it was taken. The cotton is then immersed in vat 2, and again freed from the absorbed acids by the separator, the table, prior to such separation, being turned so that the acid from the discharge of the separator will be delivered to vat 2, from whence it came. In the same manner the cotton is dipped in succession in each vat, and the surplus acid squeezed from it back into its appropriate tank. After successive charges of cotton have thus been treated the acid becomes weakened or spent, that in the first vat of the series to the greatest degree, and

in each succeeding vat to a less extent. As long, however, as the strength of acid in the last vat is sufficient to secure the desired result and there remains in the first vat sufficient strength to partially convert the cotton, no replenishing of the acid is necessary; but as soon as the acid in the first or last vat of the series falls below the required strength, the spent acid from vat 1 is replaced by fresh, strong acid; thus, in the order of the strength of acid contained in them, vat 2 now becomes the first of the series or that containing the weakest acid, and vat 1 the last of the series. The subsequent charges of cotton are then immersed in vat 2 first, and in vat 1 last, until the spent acid in vat 2 is replaced by fresh, strong acid, when in its turn vat 3 becomes the first of the series, and so on. In this way all the suitable properties of the acid are utilized, the weakest acids becoming weaker by the partial conversion of the cotton which they affect, while the last immersions of each charge of cotton are in the strongest acid.

The invention is not limited to the special apparatus described, in which a conventional form of centrifugal separator is employed; and any suitable means may be used for expressing the acid from the cotton.

He claims as his invention:

1. The method of manufacturing gun-cotton by immersing or treating charges of cotton in a given order in each of a series of receptacles or vats of acid, and as the acid in said vats becomes spent or weakened, replacing the weakest acid of the first vat of the series with fresh, strong acid, and changing the order of immersion or treatment of the succeeding charges of cotton in accordance with the relative strength of acid in the series of vats.

2. The method of manufacturing gun-cotton, which consists in immersing or treating charges of cotton in a given order in each of a series of tanks or vats of acid, and expressing from the cotton the excess of acid taken up by it and returning such excess to the vat from whence it was taken, then as the acid in said vats becomes spent or weakened, replacing the weakest acid of the first vat of the series with fresh, strong acid, and changing the order of immersion on treatment of the succeeding charges of cotton in accordance with the relative strength of the acid in the series of vats.

Hilaire De Chardounet, of France, has been granted U. S. Letters Patent No. 455,245, dated June 30, 1891. He also holds an English patent for the same invention.

The invention introduces certain improvements in the manufacture of nitrocellulose or pyroxyline, which pertain to the processes of nitration and washing, and the recovery of the acids.

It is said that the processes used permit the reduction to a minimum of the waste of acids, and the obtaining a pure pyroxyline, the nitration of whose fibers differs only in a very small percentage.

The nitration is effected by introducing cotton fiber or any other cellulose (ramie, hemp, purified wood pulp, rags, etc.), previously well dried by heat, into large pots previously filled about three-quarters full with the acid mixture, prepared in the ordinary proportions and kept at a fixed temperature by a steam-jacket. The concentration of the acids and the temperature are determined, as usual, by the degree of nitration desired; *e. g.* if it is desired to obtain a soluble pyroxyline, to one kilogram of dry cotton use twelve liters of nitric acid at the density of 1.34, and 18 liters of sulphuric acid at the density of 1.83. After leaving to soak for a time, which may vary from 1 to 24 hours, or even more, the pots are raised and poured into a centrifugal machine lined with lead or caoutchouc. By this machine the acid is extracted and run off into a reservoir, after which the communication with the reservoir is shut off and the material is washed.

The washing is done by the use of a large quantity of water, and either by removing the acid fiber to a separate vat or by leaving it in the centrifugal machine, in either case taking care to prevent any increase of temperature.

The recovery of the nitric acid left in the mass by the centrifugal machine may be made as follows: The first rinsing water may be neutralized either by adding each time an alkaline carbonate, or by placing at the bottom of the vat some fragments of limestone. A new quantity of pyroxyline may then be rinsed in the same water without inconvenience, and this may be repeated successively until this water is sufficiently charged with nitrate to be advantageously evaporated. The nitrate of lime, if desired, may be transformed into alkaline nitrate by sulphate of soda (always existing in abundance in the manufacture of nitric acid), and the nitrate of soda, after being revivified, may serve anew in the manufacture of nitric acid. After the first rinsing the material is deposited in a centrifugal machine so constructed that it may be filled with water. The first centrifugal may serve the purpose if thus constructed. The material is then successively dried by the centrifugal action, and washed with a large

quantity of water while turning the machine slowly. This succession of drying and washing permits a perfect cleansing to be rapidly effected by twelve or fifteen alternations. All the washings should be made with pure water as cold as possible. For wetting the fiber between the centrifugal drying operations the machine may be turned slowly and the water thrown on the mass of pyroxyline; but the water must be very pure in order not to leave any deposit in the mass.

It is claimed the invention has the following defined novel features or improvements, viz. The described improvement in the manufacture of pyroxyline, consisting in the successive steps of nitration, centrifugal extraction of spent acids, washing of the pyroxyline, and neutralization of the wash water by an alkaline or basic material for the recovery of the residue of nitric acid left in the pyroxyline by the centrifugal action.

The described improvement in the manufacture of pyroxyline, consisting in the successive steps of nitration, centrifugal extraction of acids, washing with water to remove the acid left after the centrifugal extraction, neutralization of the acid in this water, and its re-use with successive quantities of pyroxyline, and successive alternations of washing with water, and centrifugal dryings of each quantity of pyroxyline.

In his description of the "Preparation of Cotton-Waste for the Manufacture of Smokeless Powder," *Centrbl. f. Textil. Ind.* **21,** 975; 1890, A. Hertzog states that the military authorities require a cotton which, when thrown into water, sinks in two minutes; when nitrated, does not disintegrate; when treated with ether, yields only 0.9 per cent of fat; and containing only small traces of chlorine, lime, magnesia, iron, sulphuric acid, and phosphoric acid. The waste from the spinning machines and the looms is boiled with soda-lye under pressure, washed, bleached with chlorine, washed, treated with sulphuric or hydrochloric acid, washed, centrifugaled, and then dried. When the cotton is very greasy it is first boiled with lime water. The loss in these treatments varies largely; for example: Moisture, 3–15 per cent; packing, and in transit, 2–5 per cent; boiling and washing, 5–40 per cent; bleaching, 1.5–20 per cent.—*J. Soc. Chem. Ind.* **10,** 161; 1891.

U. S. Letters Patent No. 420,445, of February 4, 1890, have been granted Joseph R. France, who claims to have invented certain new

and useful Improvements in Soluble Nitrocellulose and its Process of Manufacture.

According to his statement, soluble nitrocellulose as hitherto made is not uniform in its character and qualities. His object is to secure an article that is uniform in these respects, and therefore reliable for the purposes to which it is adapted, and this by an easier and more certain process than that hitherto employed.

Heretofore it has been customary, according to one method, to first free the cotton from impurities by washing it in an alkaline solution; second, wash it in pure water; and third, dry it. It is then passed into a bath containing the mixed acids, which are kept at an even temperature of about 60°, by means of ice in hot weather and warm water in cold weather, and there allowed to remain for a length of time, according to the condition and nature of the fiber, the strength of the acids, etc., until the desired chemical changes are supposed to have taken place. When it is removed, the acid is first pressed out by repeated plunging into clear water. Some objections to this method of treatment are, that the action of the mixed acids upon the cotton fiber is slow, irregular and imperfect, and cannot be subjected to any uniform rule. Both expense and care are required to maintain the even temperature, notwithstanding which, some lots will reach the point of "nitration" much sooner than others, necessitating constant watchfulness.

His explanation of the slow, irregular and imperfect action of the acids in the above-mentioned process is, that however uniform the mixed acids may be in strength and proportions, and however carefully the manipulations may be conducted, there are variable elements found in different samples of cotton which defy prognosis and defeat any regular system of rules. The cotton fiber has for its protection a glazed surface, as it were, enameled by nature. It is tubular and cellular in structure, and contains a natural lubricating semi-fluid substance, composed of characteristic oil, or gum, or water, or other material, or a combination thereof. Both the glaze and the lubricating substance vary with the soil, the climate and other accidents of growth, as do other characteristics of the fiber. The tubes of the fiber seem to be open at one end only, when the fiber is of normal length.

Some or all of these elements play their parts in resisting or otherwise modifying the action of the acids upon the fiber. When the cotton is subjected to the action of the acids in its natural state and

length of fiber, the line of least resistance seems to be by way of the inside of the tubes constituting the fiber of the cotton, into which they are taken in part by capillary attraction, subject to change themselves as they progress, and to the increased resistance from the oil or the gum, etc., in their progress, and therefore to modified action, the result of which is slower and slower and otherwise more and more imperfect chemical change. It may also be that the power of capillary attraction is balanced in the tubes by air contained therein, after a little, sufficiently to prevent the acids from taking full effect. These objections he overcomes in the manner to be shown hereinafter.

Another method consists in making the cotton up into yarn and hanks, and treating it in that form with acids in the usual manner. It is found that the twisting of the fibers and the disposition in the yarn form, and the forming of hanks therefrom, causes a certain resistance to the penetration and to the action of the acids, with the result that parts of the fibers are not acted upon or acted upon imperfectly.

Still another method consists in taking paper expressly prepared from cotton fiber for the purpose, passing it through the acids, washing, drying, grinding, etc., as before described. In this last case the fibers are of course modified both by the chemical and also by the mechanical treatment to which they have been subjected in the preliminary preparation of the paper; but if the oil or gum or the glaze has been attacked by them, and if they, all of them, have been removed by subsequent washing, etc. (which is very difficult, if not impossible to do), the character of the cotton fiber itself seems to have been changed chemically, mechanically, and by felting, so that the cellulose product of the paper process is not uniform or otherwise always satisfactory. In all these methods temperature is found to be an important condition.

He uses the cotton fiber in its natural state, made pure and free from extraneous substances as possible, but cut, pulverized or ground in advance as fine as possible, even to a dust, by the mechanical means and to the extent set forth in an application filed by him February 5, 1884, Serial No. 119,845, and in that condition subjects it to the acids and to all the subsequent manipulations required to produce soluble nitrocellulose, to be described hereinafter. The principle of his method is that, whereas in the first-named old process the acids attack the fiber, say of half an inch or an inch in length, from one

end and the outside, in his process, when any natural cotton dust is used, each particle will have two more mouths or openings by which the acids can enter for every additional piece into which the fiber is cut, and in addition the glaze of the fiber may be broken up by the cutting, rubbing and grinding operations to which it is subjected in advance, thereby giving the acid a better opportunity for external attack as well. In his method the cotton fiber becomes a homogeneous mass of particles or dust, consisting of very small bits of the material, each one of which is attacked by the acids and by coming in contact with the same, the result being uniform in character in the time required for nitration, and also in the uniform equivalents of nitrogen taken up in producing the desired product.

The cotton dust is placed in a bath containing the mixed acids in the usual well-known proportions required to produce the article at any ordinary temperature—between 40° and 90° F.—and allowed to remain for a uniform length of time, in proportion to the strength of the acids, until the point of nitration is reached. The surplus acids may be removed by pressure or extraction, or the nitrocellulose may be left in the acids for an indefinite length of time, according to convenience, without change, or injury, as in the process now in use.

He states that: "In my process I avoid several of the operations employed in the methods previously described, and I substitute an improved base or material to be treated, having superior qualities for the purpose, which enable me to omit some of the steps required where other base material is used, as follows:

"1. I do not find that it is necessary to wash either the cotton fiber or the cotton dust in any alkaline solution. Consequently, I omit that operation entirely, and find that I produce a superior article of nitrocellulose when it is omitted, and this with certainty in each and every instance.

"2. The washing in pure water and the drying are therefore omitted also.

"3. The watching and constant attention to the temperature I also avoid.

"4. I avoid the loss of material which occurs from premature or imperfect nitrations, and the danger of spontaneous combustion.

"5. I avoid the want of uniformity in the resulting product.

"6. I avoid both capillary obstruction and much of that arising from the enamel or glaze of the fiber.

"Among the advantages resulting from the use of my cotton dust are the following:

"1. The product is always uniform both in appearance and chemically, and will remain stable for a long period.

"2. It is always evenly soluble.

"3. It is not liable to spontaneous combustion.

"4. The remaining acids are more easily and more thoroughly washed out after the point of nitration has been reached.

"5. My soluble nitrocellulose can be more cheaply produced, since waste is avoided and time is saved in washing.

"6. Less watching of the process of nitrogenizing is required.

"The fact that the cotton is in the form of dust, and in that finely comminuted form is acted on more quickly and perfectly by the acids, is important also, and has its proper effect in the washing stage above mentioned, giving more prompt and complete access to the water and egress to the acids.

"The soluble nitrocellulose made from my cotton dust is distinguishable from its cotton dust base by its explosive quality, and by a certain dull uniform massed and slightly felted appearance, showing that it has not been subjected to mechanical disturbance subsequent to its subjection to the action of the acids. In other respects it corresponds in appearance to the cotton dust from which it is made. It is distinguishable from the highly explosive or insoluble nitrocellulose by the fact that it can be dissolved in the usual preparation of ethyl, or grain alcohol and ether, as used in making collodion, or in methyl or wood alcohol of 95 per cent to 100 per cent. It is distinguishable from soluble nitrocellulose made by the old process, which has been reduced to dust subsequent to subjection to the acids, by its appearance, as above stated, showing that it has not been subjected to mechanical disturbance subsequent to its subjection by the action of the acids.

"In practicing this invention I find that taking one-pound batches of finely ground cotton, which is immersed in the mixed acids of varied proportions according to solubility required for a good soluble nitrocellulose, a proportion of eight (8) parts nitric acid 42° Beaumé and of sulphuric acid twelve (12) parts 66° Beaumé, is suitable. The cotton is stirred into the bath of mixed acids for fifteen (15) minutes, the superabundant acids are pressed out, and the cotton then washed in successive waters until entirely free from acids. Using cotton dust, I can thus nitrate effectively at an ordinary temperature—say from 50° to 100° F. I usually prefer to keep the room in which the nitration is carried on at a temperature of about 75° F., but I find no

perceptible difference in the nitrations at ordinary temperatures, as before stated, and I attribute the advantages over the old methods here indicated to the use of the cotton dust, as stated herein; but I do not desire to limit my invention either to the exact proportions of the acids or to the exact temperature above set forth, as by the use of my cotton dust I am able to vary the range both of proportions and of temperature greatly and yet accomplish the purpose of my invention in a superior manner.

"I am aware that it is not new to produce an impalpable powder from cellulose by the use of chemicals and afterwards treat the same for the production of pyroxyline or nitrocellulose, and this I do not claim."

What he does claim, as his invention, is as follows:

1. The process of making nitrocellulose, which consists in mechanically reducing cotton to a uniform and homogeneous dust-like condition, and then subjecting it to the action of a bath of nitric and sulphuric acids in about the proportions and at the temperature stated.

2. The process of making nitrocellulose, which consists of subjecting mechanically comminuted cotton in a homogeneous dust-like condition to the action of a bath of nitric and sulphuric acids in about the proportions and the temperature stated.

3. As an improved article of manufacture, soluble nitrocellulose composed of pure mechanically comminuted cotton fiber nitrated, substantially as described.

U. S. Letters Patent No. 457,002, August 4, 1891, have been granted Ebenezer Kennard Mitting, for a "Process of Making Nitro-Glycerine." In his specification, after referring to the usual manner of making nitroglycerine in the three varieties known to chemists as mononitro, dinitro, and trinitro-glycerine, and of which the trinitro is the only variety which is of practical utility as an explosive, he states that the operation is defective, owing to the fact that the last portions of the glycerine added to the acid are not converted into trinitro-glycerine, by reason of the weakening of the acid mixture by the water formed in the reaction earlier in the operation, the presence of a comparatively large excess of anhydrous or nearly anhydrous nitric acid being essential to thoroughly convert the glycerine into trinitro-glycerine. Consequently the full theoretical yield of nitro-glycerine (or a close approach thereto) is never obtained in practice,

a certain loss always resulting from such portion of the glycerine which has not been converted at all, or only converted into the mononitro variety, being dissolved in and carried away by the wash water, while another and variable proportion may have been converted into the dinitro variety, and a portion of this may remain after washing together with the bulk of the trinitro, reducing its specific gravity and explosive force. Various means have been proposed to overcome this defect and improve the yield of trinitro-glycerine. It was thought that the admixture of the acid with the glycerine in thin streams, allowing the whole to presently run into a collecting tank, would overcome the difficulty; but this device did not succeed, owing to the fact that the reaction is not completed, except (as stated above) in the presence of a large excess of anhydrous nitric acid. Consequently the same conditions were brought about in the collecting tank as obtained in the case of running the whole of the acid first into the tank and then adding the glycerine slowly, viz. that the last portions of the glycerine were not fully converted. Again, it was proposed to first treat the glycerine with only a portion of the usual amount of acid to remove the spent acid and then treat with the remainder, and for the better prosecution of this process to vary the quality of the acids used for the first and last treatment, and even to make the process a continuous one. So far as he was aware, this mode has not proved successful in practice, because it fell short of providing the necessary excess of nitric acid at the close of the operation. It has also been proposed to use double and treble the usual quantity of acid; but this device has not been successful, and on the other hand the cost has been so largely increased as to be almost prohibitive.

The object of his invention is to overcome the difficulty above set forth and to convert the whole or practically the whole of the glycerine into trinitro-glycerine, and thus produce a yield more nearly approaching the theoretical quantity, and to effect this improvement without the use of additional acid beyond the usual quantity now employed.

In carrying his invention into effect, he first proceeds with the nitration of the glycerine in the usual manner, viz. by charging the nitrating vessel with the mixed acid, say about 8 parts, by weight, for every 1 part of glycerine to be nitrated, and at the close of the operation and after separation has taken place he draws off the spent acid in the usual manner. In the meantime he prepares another lot

of mixed acid for the next succeeding lot of glycerine; but before using it for such next lot he runs into and mixes with it the nitroglycerine produced from the first operation. The effect of this is to expose the nitroglycerine produced in the first operation to the full effect of the large charge of anhydrous nitric acid intended for the second operation, and thus convert any of the lower nitroglycerine into the trinitro variety. After allowing the mixture to settle he draws off the supernatant trinitro-glycerine to the washing tanks and proceeds with the nitration of the second lot of glycerine with the acid (originally intended for it) in the usual way, and the nitroglycerine thus produced is in its turn fed into and mixed with the lot of acid for the next succeeding nitration, and so on continuously, using always the fresh acid first upon the last preceding lot of glycerine which has been nitrated, and then to nitrate a fresh lot of glycerine, as described. The fresh acid after acting upon the product of a previous nitration contains a little water, such water being that produced in the reaction, as will be readily understood. This, however, is of comparatively small amount and does not seriously affect the succeeding nitration, especially as same is in reality completed by exposure to the next lot of fresh acid.

The foregoing operations he performs in one nitrating vessel by proceeding as follows: he first nitrates a charge of glycerine in said nitrating vessel and allows the mixture of nitroglycerine and spent acid to settle and separate, and then draws off the spent acid only, leaving the nitroglycerine in the nitrating vessel. He next runs into that nitroglycerine the charge of mixed acid intended for the next nitration (this operation is performed quickly and with perfect safety under the usual precautions), and having mixed the liquids he allows them to settle and separate, and next draws off the supernatant nitroglycerine (to be washed and otherwise dealt with) by a faucet fixed at a proper level, or equivalent means, leaving the acid in the nitrating vessel ready to receive a charge of glycerine, which he now runs into it. He next allows the mixture to settle and separate, draws off the spent acid, and proceeds to run into the nitroglycerine the charge of fresh acid, as before, and so on in regular order, as described; or two or more nitrating vessels may be employed and preferably fixed at different levels, as will be readily understood by those versed in the art. By working in this manner an increased yield of nitroglycerine is obtained, of full specific gravity and explosive power, without increased quantity of acid beyond that usually

employed, and at only a slightly increased cost for manipulation, which is more than repaid by the increased yield, quality, and safety, as the fully converted trinitro-glycerine is far less liable to spontaneous decomposition than a mixture of such nitroglycerine with lower nitro compounds.

He claims:

1. The improvement in the method of manufacturing nitroglycerine, which consists in first nitrating a charge of glycerine and separating the product from the spent acid, then treating said product anew with a fresh charge of nitrating acid in excess, and finally separating the nitrated glycerine from the fresh excess charge of acid, substantially as described.

2. The improvement in the method of manufacturing nitroglycerine, which consists in first nitrating a charge of glycerine and separating the product from the spent acid, then treating said product anew with a fresh charge of nitrating acid, separating the nitrated glycerine from the acid, and employing the acid to nitrate a second charge of glycerine, substantially as described.

3. The improvement in the method of manufacturing nitroglycerine, which consists in first nitrating a charge of glycerine and drawing off the spent acid, next treating the product with a fresh charge of nitrating acid, then drawing off the nitroglycerine and nitrating a fresh charge of glycerine with the same acid, and repeating the operation in the same nitrating vessel, substantially as described.

The *Scientific American Supplement* **27**, 11070–11071; April 13, 1889, copies from *La Nature* an article by M. Vuillaume, late director of the dynamite factory at Cengio, Italy, on the "Manufactures of Nitroglycerine," which is illustrated by a number of drawings showing the apparatus used and the method of working it.

Eduard Liebert, of Berlin, has been granted two patents for methods of treating nitroglycerine. In the first he seeks to render nitroglycerine uncongealable by adding to it isoamyl nitrate. This addition, while it may not prevent freezing in all cases, is likely to weaken the effect considerably. In the second, he adds ammonium sulphate or nitrate to the acid mixture during nitration, to destroy the nitrous acid formed according to the following equation:

$$(NH_4)_2SO_4 + 2HNO_2 = H_2SO_4 + 2N_2 + 4H_2O.$$

—*Ding. Poly. Journ.* **278**, 19; 1890.

U. S. Letters Pat. No. 449,687, April 7, 1891, have been granted Hiram S. Maxim for "Process of and Apparatus for Making Explosives."—Ill.

His invention relates to the manufacture of explosives of the kind or class known as "nitro compounds" or "nitrated explosives," such as nitroglycerine, gun-cotton, and the like, which result from the combination or composition with glycerine, cellulose, or the like, of nitric acid or other suitable nitrating compounds.

In his specification he describes the invention as applied to the manufacture of nitroglycerine only; but its applicability to the treatment or manufacture of other explosive compounds of a similar nature is to be understood.

The main objects of the invention are, first, to produce any desired quantity of an explosive by a continuous process or operation, and, second, to bring the acid or nitrating agent and the glycerine, or other material to be acted upon thereby, into intimate contact with each other while both are in a very finely divided condition. These objects he accomplishes by bringing the glycerine or other material in the condition of spray into a stream or current of acid spray.

In carrying out the invention practically, the mixing of the nitric acid or nitrating agent and the glycerine is effected by means of an injector operated by cold compressed air or by a cold air blast. The suction produced by the current of air flowing through a nozzle forming a part of the injector, draws the glycerine from a tank in which it is contained, and the current of air impinges upon and atomizes the glycerine, or scatters it in a fine spray. The acid is similarly drawn from another tank and blown into a fine spray, and the two substances while in this finely divided condition are caused to intermingle in the presence of air which is rapidly expanding and of which the temperature is rapidly falling. The atomized acid and glycerine are together blown into, and conveyed through, a mixing pipe or tube, and after issuing therefrom they are washed or quenched by a copious spray or jet of water, and collected in a suitable receiver.

The apparatus, as described, consists of a nozzle entering a "chamber" provided with a nozzle, entering the enlarged end of a "tube," the three concentric parts forming a double injector, of which the inner or first nozzle is connected with a receiver of air compressed by a suitable pump to a pressure of about 100 pounds to the square inch. Which pipe enters the "chamber" back of the orifice of the inner or first nozzle, contains a suitable cock, and leads from

a tank or receiver. A second pipe, provided with a cock, leads from a second tank or receiver and enters the "tube" back of the orifice of the nozzle of the "chamber." One of the tanks is to contain the acid or nitrating agent and the other the material to be combined therewith, and both are provided with glass gauge tubes to indicate the levels of the liquids therein.

The first mentioned "tank" is filled with glycerine, and the other, to the same level, with acid. The air is then allowed to flow through the first or inner nozzle. The current of air issuing from this nozzle produces a partial vacuum in the "chamber," which, upon opening the cock of the pipe connecting with the tank of glycerine, draws the glycerine in. The air impinging upon the glycerine atomizes it and forces it in a spray through the nozzle of the "chamber." The air-jet and spray issuing from this nozzle produce in like manner a partial vacuum in the "tube" back of the orifice of said nozzle, and this draws in the acid, which, meeting the jet, is blown into spray and mixed with the atomized glycerine. The air being kept under a high pressure in the reservoir, a considerable amount of refrigeration will take place in the nozzle of the "chamber" and in the "tube" by reason of its expansion in these places, and the temperature of the acid and the glycerine will thus be prevented from rising too high.

The "tube," into which the atomized mixture of acid and glycerine is blown, serves as a mixing chamber, and should be of considerable length, so that the materials may have ample time while in the same to complete their reactions on one another in the manner required. It may be from 1¼ to 1½ inches in diameter at the part which surrounds the injector nozzle, and for a distance of, say, 16 inches, or thereabout, from the said injector, and may gradually increase in diameter beyond this point until it reaches a collecting tank. It is, moreover, advantageous to arrange said "tube" with a fall toward the collecting tank of about 1 in 15.

The length of the "tube" or mixing pipe may be from 100 to 200 feet, more or less, and a wall or mound of earth may be built between the injector and the collecting tank to serve as a protection to the operator. The "tube," as well as other parts of the apparatus, may be surrounded by a water-jacket, through which a circulation of cool water is maintained for keeping down the temperature of the explosive compound.

Prior to entering the collecting tank the current of spray is met by a stream or a number of jets of cold water from a nozzle inserted in

the top of the collecting tank above the "tube" or mixing pipe, which serves to cool or quench it as it enters the collecting tank.

The tanks for containing the acid and the glycerine are preferably arranged side by side above the injector and mixing pipe or "tube," and should be made of such relative capacities or dimensions that they will contain the required proportions of acid and glycerine, and will therefore both be emptied at the same time.

The quantity of explosive material operated upon at any time is very small. The collecting tank should, however, be of large dimensions, so that it will contain a great quantity of water.

The acids and glycerine being blown into a fine spray, as above described, an instantaneous nitration will be effected, while the expansion of the air, as it issues from the injector, serves to lower the temperature. Moreover, it is claimed for this apparatus that the chemical reaction may be readily controlled, and that, should any undue production of heat take place or nitrous fumes be developed, the supply of air to the injector may be increased and the temperature thus brought down.

In cases where the space available for the apparatus does not admit of the use of a long mixing pipe or "tube," such as is described, the "tube" is carried direct to a tank surrounded by a water-jacket. A pipe leads from this tank, from or near its bottom, back to the mixing chamber or space at the rear of the nozzle of the "chamber." This pipe contains a cock, which, while the atomized acid and glycerine are being mixed, is closed. When a quantity of explosive has been thus made, the acid and glycerine supply pipes are closed and this cock opened. The continued flow of air under pressure produces a rapid flow of the mixture from above pipe back into the collecting tank. The expanding air with its refrigerating effect keeps down the temperature, while by the circulation and agitation the substances are thoroughly and intimately mixed.

An air vent is provided in this collecting tank, and the same disposition as in the previous case may be used for quenching the mixture by jets of water.

The subsequent treatment of the nitroglycerine or other compounds made by this process may be the same as in the case of similar compounds as hitherto manufactured.

What he claims is:

The method or process of manufacturing explosives as described, which consists in separately atomizing or finely dividing the nitrating

agent and the material to be acted on thereby, and uniting the two or causing them to intermingle while in such condition.

The continuous process described of manufacturing explosive compounds, which consists in uniting and causing to intermingle jets of the acid and material to be acted on thereby, in the condition of spray, carrying off the spray in a mixing chamber, and collecting the resulting compound in a tank or receiver.

The method or process described, which consists in atomizing or spraying glycerine by a jet of air under pressure, separately atomizing or spraying in a similar manner a nitrating agent, and mixing the two substances while in the condition of spray.

The method or process of manufacturing explosives, which consists in separately atomizing and uniting the spray of the nitrating agent and the substance to be acted on thereby, and then quenching the mixture with water.

The combination of a nozzle, a receiver or source of compressed air connected therewith, a tube or chamber surrounding the nozzle, a tank or receiver for glycerine connected with said chamber, a second chamber, and a tank or receiver for acids connected with the same, the first chamber being formed with a contracted nozzle that enters the second or mixing chamber, the above parts being arranged in substantially the manner as set forth to constitute an injector for atomizing and mixing glycerine and acid.

The combination, with a collecting tank, a mixing tube or chamber leading thereto, and a nozzle or means of quenching with water an explosive mixture delivered from the mixing tube into the collecting tank, of an injector at the end of the mixing tube, tanks for containing acid and glycerine, respectively, connecting with the injector, and a receiver or source of compressed air for operating the injector.

The combination with a receiving tank and mixing tube or chamber, of two concentric injector nozzles, receivers for containing glycerine and acid, respectively, connected to the chambers surrounding the nozzles in the rear of the orifices of the same, and a source of compressed air, as set forth.

In discussing "Precautionary Regulations during the Preparation of Nitroglycerol," F. Scheiding, *Zeits. f. angew. Chem.*, 1890, 609–613, first suggests that the mixing of the acids should be made in a vessel provided with a cover and chimney for conveying the acid fumes out of the building. The mixing can be effected by means of

compressed air, and the cover prevents any of the acids from being thrown out of the vessel. Montéjus should be made of cast or wrought iron, preferably not lined with lead. Cast iron withstands the action of the acid better than wrought iron, but is liable sometimes to crack, especially when the air-cock is opened. This cock should therefore be placed outside of the building or separated from the montéjus by a wall, and the montéjus should stand clear of everything, so that any leak can easily be observed. In the next operation, which properly may be called dangerous, viz. the nitration of the glycerine, rise of temperature which might lead to explosion may be caused by impure glycerine or the accidental admixture of water. The chemical examination of the glycerine is therefore essential.

The nitrating vessel must be made of thick lead and stand clear on all sides in a well lighted building, yet not exposed to the direct rays of the sun. The contents of the nitrating vessel should be kept cool by several separate coils of thick leaden pipe, through which cold water passes. In order to prevent any water from escaping into the acid mixture, should one of the worms be damaged during the operation, the cooling water should flow from a higher lying vessel and discharge into a lower lying tank. The cooling worm would thus act as a syphon and draw some of the acid and nitrogen mixture into the lower tank, where its presence would be recognized by the turbidity produced, or by means of litmus paper. The agitating or stirring is best effected by compressed air, and the workman should always ascertain by means of a manometer whether there is sufficient air pressure before commencing the nitration. In order that no water may be carried over with the air, a condensation box should be fitted at the lowest point of the air pipe. The nitrating vessel must be provided with a cover or hood and chimney, which will convey the acid fumes out through the roof. The whole apparatus should stand over a large tank containing water, into which the whole contents of the nitrating vessel can be promptly discharged through a large earthenware cock, should the temperature rise to 40° C.

The floor of this building in certain districts consists of sand, in others of clay. The author prefers a clay floor slightly sloping towards a gutter in the middle which passes underneath the door. The floor should be kept always damp and covered with sawdust, and the place where the men stand covered with a soft mat. The mat should be washed twice a week, and the sawdust renewed once a week and the removed sweepings burned.

The author suggests the erection of one or two shelter huts, in which one or two workers could take refuge when an explosion threatens, and be protected from falling pieces. An alarm horn should be hung in the shelter hut, by which a warning signal could be given for the whole factory. As explosions have been caused in other buildings by debris falling through the roof, the author advises that the roofs of the buildings in which nitroglycerine or dynamite is present should be provided with a strong double lining. The intervening space would also keep the building cooler in summer and warmer in winter. An electric bell should be near the nitrating apparatus, by which a signal could be sent to the laboratory in the event of anything unusual occurring during the operation. The plug of the discharge cock should be carefully examined before each operation to see that it is quite free from any grit or frozen nitroglycerine.

For conducting the nitroglycerine and waste acids through the mound surrounding the building, a brick channel thickly covered with tar is recommended, just sufficiently wide to take an open leaden gutter, through which a leaden pipe can be pushed. This pipe can be daily cleansed by rinsing first with concentrated sulphuric acid and then with water.

The author considers the combination of the nitrating apparatus with the separator in one building as injudicious. The separator should be provided with a perforated pipe for compressed air, that in the event of heating taking place, which often occurs only at separate spots, the mixture could be agitated and the danger possibly avoided. It should also have electric thermometers which would ring a bell when a certain temperature was reached. The separator should also have a hood with chimney passing through the roof. Outside of the mound surrounding the separator house there should be a pipe for compressed air, with a cock by means of which the agitation of the liquid in the separator could be started, should the workmen have fled from the building on signs of danger without starting the air agitator. Should the bells in connection with the thermometers cease ringing, the building can safely be re-entered. An essential condition of safety is that all the apparatus should be carefully examined daily, to see if it is in proper working order. After the nitroglycerine has passed to the washing house the most dangerous operations are passed. There the greatest cleanliness should be observed and care taken that no wash water, which always

contains some nitroglycerine, is splashed about. The nitroglycerine must be washed quite free from acid.

Dr. Thomas Darlington, in treating of "The Effect of the Products of High Explosives, Dynamite and Nitroglycerine, on the Human System," says in the *Medical Record* 38, 661–662; 1890: When dynamite or nitroglycerine is used in open-cut work, as on our railroads, after the explosion the gases immediately distribute themselves in the atmospheric air, and no effect has been noticed on the workmen employed. But when used in tunnels, as in mining or other partially closed cavities, where the gases or residues are slow to escape from the mouths of the tunnel, or up air shafts, serious deleterious effects are produced.

There are, for purposes of study, practically two classes of dynamite, which might be termed inorganic and organic, according to the absorbent used. A type of one class is that made with infusorial earth, and of the other, that made with wood pulp or sawdust. Others still are made from a combination of both. The results of the explosion, however, are practically the same in either case, except that with the organic absorbent we get with the products an additional amount of carbon.

An experience of over five years where such explosives have been in use has led me to believe that an article on this subject might be of interest to some of the medical profession.

During 1885 to 1887, while surgeon to the New Croton Aqueduct, fully thirteen hundred cases of asphyxia, or partial asphyxia, and poisoning, from the products produced by the explosion of dynamite, came under my care; and more recently a few other cases which I have had better opportunity to study.

Two classes of cases were observed: First, where a considerable quantity of the products was inhaled at one time—acute cases; second, where the men constantly breathed a small amount, or chronic cases. The acute cases varied according to the amount inhaled.

In some cases where the amount of dynamite used was not large, or where, after the explosion, a considerable quantity of fresh air has been mixed with products of combustion, or where the workman has after a few breaths become giddy and is pulled away by others and sent to the surface, the effects produced are a trembling sensation, flushing of the face, succeeded sometimes by pallor, frequently

nausea, sometimes vomiting, with throbbing through the temples and fullness in the head as if it would burst, followed by an intense headache characteristic of poisoning by nitrites—similar to that of nitrite of amyl, only not so violent, but more persistent, frequently lasting forty-eight hours. The heart's action is increased, and the pulse full and round, though somewhat compressible.

Case I.—J. C——, occupation miner, while returning to work after a blast, became dizzy, and crawled on hands and knees back to the bucket; felt as if drunk. About twenty minutes afterward was nauseated and vomited slightly. Had a feeling as if his head was swelled. After vomiting the headache increased. The pulse at this time was full and bounding and 108. Ten hours afterward the headache was more pronounced, and the pulse 88 and more compressible.

Where, however, a man goes into the tunnel immediately after the explosion, and is brought in contact with a large percentage of the poisonous materials, the effects are giddiness immediately followed by unconsciousness, and the patient presents the usual appearance of asphyxia. Sometimes in these cases the pulse is full and bounding, though very compressible; but in most of the cases it is alarmingly weak. Generally there is great pallor, though this may be partially due to working underground. The comatose condition soon passes away, and is succeeded by drowsiness, languor, cold perspiration, intermittent pulse, and generally nausea and vomiting. Sometimes the breathing is spasmodic, and frequently there is hiccough, and after a time a severe headache.

Nearly all of these cases, however, no matter how serious they seem at the time, recover; though a substitute on the Aqueduct, during my absence, was on one occasion so unfortunate as to lose two cases. I found upon inquiry that death in these cases occurred several hours after the patients were removed from the tunnel, and was due to paralysis of respiration.

In the chronic cases there are four prominent symptoms: Headache, cough, indigestion, and disturbances of the nervous system.

The cough is similar in character to the cough of pertussis or of malaria, and at first I was under the impression that it was purely malarial, as cases of intermittent fever were frequent. But although some of the cases may have been complicated with malaria, there were many others that were not, in which the cough was persistent.

In nearly all of the cases there was a continuing headache.

Next in prominence to these symptoms come disturbances of the nervous system, as trembling, irritability, neuralgia, etc. In fact, nearly if not all of the symptoms were attributable to this cause. Even the cough, in all probability, was due to the effect produced on the pneumogastric nerve.

One of the superintendents became so nervous and irritable, largely from this cause, that it was with difficulty that he could get along with the men. All of the men affected seemed extremely nervous. And with this was associated indigestion, probably due to the same cause. Of course, with this latter symptom, the character of the food and the manner in which it was eaten must be taken into consideration. But as soon as a man with these chronic symptoms was taken from the tunnel and placed at work on top, he steadily improved, and would finally recover entirely.

It was also noticeable that those who had previously suffered from dyspepsia or neuralgia were made much worse by the dynamite smoke.

One inspector on the Aqueduct was forced to resign by reason of the constant return of an old "tic douloureux," due to this cause. What were the symptoms recognized due to?

The formula for nitroglycerine is $C_3H_5(NO_3)_3$. And the products from the combustion of this are written:

$$4C_3H_5N_3O_9 = 10H_2O + 12CO_2 + 6N_2O_2.$$

In other words, the products are water, carbonic acid gas, and nitrogen dioxide; none of which would produce the symptoms above described except asphyxia, but not the effect on the heart, nor the other symptoms witnessed. What then was the cause?

A comparison of the above symptoms in the acute cases with the phenomena produced by various sized doses of nitroglycerine shows them to be identical. This similarity of symptoms from inhalation of the products of the explosion of dynamite, and of those produced by the nitroglycerine itself, is so well marked that even miners themselves have noticed it. Frequently, when dynamite is frozen, a miner will place a cartridge in his boot to thaw it out; and the absorption of nitroglycerine through the skin will produce precisely the same symptoms as in the mild acute cases of the inhalation of the products before described.

Again, I know an instance of where a miner used his knife to cut a cartridge, and afterward cut and ate an apple with the same knife.

In this case, according to his statement, the symptoms were similar to being "knocked out by powder smoke," only more severe. The headache persisted three weeks. And on another occasion this same miner cut up some tobacco to smoke, with a knife that he had used for dynamite, and was again similarly affected. Here the heat from the tobacco inhaled smoke volatilized the fine particles of nitroglycerine on the tobacco below, and poisoning was produced by absorption through the lung tissue.

No other conclusion can well be reached than the fact that there is mixed with the gases produced, unexploded particles of nitroglycerine in a volatile state, and these particles inhaled by the miners produced the effect described.

There is no doubt but that the explosion of a large quantity of dynamite would produce sufficient gases of CO_2 and N_2O_3 to produce asphyxia. Here we get the cyanosis and other symptoms of simple asphyxia, and we may get nausea and vomiting; but not the same disturbance of the sympathetic system, nor the continued chronic spasms of the vagus, nor the persistent headache pathognomic of nitroglycerine poisoning. This fact can be conclusively proved by waving in the fumes, immediately after an explosion, a cold sheet of glass, and thus collecting upon it by condensation a small percentage of the nitroglycerine itself.

As regards treatment, as a preventative, the use of such apparatus or machinery, whether by blowing or by sucking, as will rapidly clear the tunnel or cavity from noxious gases or fumes is to be recommended. Where steam drills that are worked with an air compressor are used, they contribute largely to this end.

Also it has been found by makers of dynamite that the use of a large cap will explode a greater percentage of the glonoine than a small one, and this, to a certain extent, obviates the trouble. In certain cases, however, for some reason, a cartridge does not explode, but burns like a candle, with considerable sputtering. In such an instance the amount of nitroglycerine volatilized is much greater than if exploded, and consequently the effects far more deleterious. I have witnessed a whole "shift" "knocked out" from this cause.

Of course, such measures as are generally used in cases of asphyxia are of service. But in addition to these, the use of cold to the head, and of atropine, ergotine, or other vasomotor stimulants, administered subcutaneously, are of necessity indicated and exceedingly efficacious. There is little doubt that the effects of nitroglycerine

are produced from its decomposition and the formation of a nitrite in the body. "Treatment with ammonia restores normal color and normal functional power to nitrite-poisoned blood."

Acting on this principle, and from its stimulant properties, I have uniformly treated my cases with inhalation of ammonia, and also given the carbonate and aromatic spirits of ammonia internally; and up to the present time have not lost a case.

It seems to me it would be well for those in charge of such works to recommend to the workmen to carry with them small vials of this remedy for use in similar cases.

In none of the cases did I notice any changes in the blood—that is, darkening—such as are mentioned in nitroglycerine poisoning, but this may have been due to lack of proper observations on my part. In numerous cases of pneumonia the sputum was darker than usual, but this I attributed to the dust and lamp-smoke inhaled.*

According to W. Schuckher's English Patent 45,625, Sept. 16, 1890, for "A Process and Apparatus for the Manufacture of Nitrated Starch," starch, preferably potato starch, is dried at 100° C. and finely ground. It is then dissolved at 20°–25° C. in nitric acid of 1.501 sp. gr., using 10 kilos. of acid to 1 kilo. of starch. The solution is added to a mixture of nitric and sulphuric acids, which, for sake of cheapness, may be the waste acid from nitroglycerine manufacture, containing about 70 per cent of sulphuric and about 10 per cent of nitric acids. Five kilos. of this waste acid are employed to every kilo. of the nitrated starch solution, the mixture being kept at a temperature of 20°–25° C. Nitrated starch is precipitated as a fine powder and is collected on a filter of gun-cotton. The bulk of the acid is then removed from the precipitate by hydraulic pressure. The cakes produced are well washed in water and treated with 5-per cent soda solution. After 24 hours the cakes are ground between rollers, the creamy mass formed being afterwards dried by means of a centrifugal machine or a filter press. Finally about 1 per cent of aniline is added to the residue, which still contains 33 per cent of water. Nitrated starch as prepared dissolves readily in nitroglycerine. In

* Bibliography: Hunt, T. Sterry: Am. Jour. of Sci. and Arts, "Glonoine," Nov., 1849; Murrell, William: Lancet, 1879, pp. 80, 113, 225; Hay, Matthew: Practitioner, June, 1883; Brunton, T. Lauder: Pharmacy, Therapeutics, and Mat. Med., 1888, "Nitroglycerine," p. 788; Curtis, Edward: Reference Handbook of the Med. Sciences, p. 189, "Nitrites."

the cold it forms at first a mass resembling lime, but as more of the nitrated starch is added a hard waxy material is produced.

A very serious accident occurred on the 13th May in a factory at Avigliana, during the manufacture of ballistite, by which 13 lives were lost. Through the Foreign Office we have obtained some interesting particulars of the accident, collected by Col. Slade, British Military Attaché at Rome. It appears that "The factory, or rather the special portion of the scene of the occurrence, is a long roofed structure, divided into five separate compartments, where the operations of milling, cutting, sifting and cleaning are carried out.

"In the first ward the ballistite, by means of a special engine, is prepared in the form of sheets, after being laid in a wooden trough fitted with double zinc plates, and subjected to the heating process by means of hot-water pipes, after which they pass to the cutting machine.

"The second ward was empty at the time of the fire, a large platform being in course of construction for the setting up of two cutting and two grinding machines.

"In the third were several cutting and granulating machines, together with a ton of smokeless powder ready prepared to be despatched to the navy.

"The fourth contained the sifting machine, and it is also supposed that upwards of two or three tons of black powder were also in the ward.

"The cleansing machine and upwards of four tons of black powder, partly packed and partly loose, were in the fifth compartment.

"All the several compartments are connected by vaulted passages, and all have an outlet by means of light glass doors; all these doors were open* when the fire broke out.

"A workman, who was standing about 70 yards off, stated that the fire broke out in the first compartment, and spread with the greatest rapidity through the other four. No dead body was found in the first ward, two were found in the fourth, and eleven crowded together at the door of the last; among these eleven were the remains of a man who at the time was working in the first compartment.

"This leads one to fairly assume that the fire originated in the

* Subsequent information throws doubt on this statement, and it seems more probable that the doors were closed, and they certainly opened inwards instead of outwards.

first compartment, either through the action of the cutting machine, or by the sudden ignition of one of the strips of ballistite through overheating.

"The bodies of the five men working in this ward were set on fire, and the poor fellows, in place of running out through the open door, fatally searched for an escape through the several compartments, thus spreading fire in every direction, to the last room, where the heat must have reached such an intensity as to have produced immediate death. All the tools and wooden implements were slightly charred, whilst the metal of those zinc-plated had completely melted away.

"The various machines did not suffer much from the results of the accident, and will be set at work again as soon as the buildings have been repaired.

"One of the walls of one of the wards was blown down and three were unroofed, the tiles falling outward. The first two wards were left almost intact. The total amount of powder destroyed may be reckoned at about 8 tons, whilst the damage is estimated at about 4000 l."

Although nothing definite is disclosed as to the cause of the accident, there can be no doubt that the manufacture was being carried on in a very dangerous manner, with a wholly unnecessary accumulation of persons and explosive material within a single building, and with a very inexcusable neglect of what in this country would be regarded as essential precautions.

It is most important (especially when dealing with a comparatively new material like ballistite) to isolate the various processes, to subdivide the amounts of material so as to limit the effects of a possible accident, and to allow only a very few work-people within a single building or risk.

None of these things were done here, and the subdivision of the buildings into wards (as the event showed) was entirely illusory.

It has been suggested (by the Italian Director-General of Artillery) that a piece of ballistite in being carried from one machine to another may have fallen off one of the trays, and that some small grit or gravel may have adhered to it, and so bronght about the explosion, when the machinery was again set in motion. This suggestion is not intrinsically improbable, but if it be accepted it would point to an even greater disregard of precautions, because one of the first efforts of the maker of explosives should be directed to the rigid exclusion of grit from danger buildings.

The one satisfactory point in connection with this accident (which in its consequences, if not in its inception, would appear to have been entirely preventible), is, that although no less than about 8 tons of ballistite is estimated to have been consumed, there was no violent *explosion*. This observation usefully supplements the results obtained in the experiments with burning the kindred explosive "cordite," which are described in the Experiment Section of this Report.*—15*th Ann. Rept. H. M. Insp. Exp.* pp. 49–50; 1891.

According to O. Guttmann, *Ding. Poly. Journ.* **278**, 25; 1890, smokeless powders have been the cause of fatal accidents at Spandau as well as at Avigliana, which are believed to have resulted from the fact that the behavior of these bodies, under all conditions of production and with novel machines, is yet but imperfectly known.

Among the accidents by fire or explosion which have come under the notice of the Home Office from January 1 to December 31, 1890, we note the following due to ballistite:

The first occurred Feb. 27, at Factory No. 3, Ardeer, Ayr (Nobel's Explosive Co., Limited):—A small "crack" occurred in the ballistite when between the rollers. The foreman felt as if something had struck his wrist, and a mark was found like the prick of a pin. Whether this was a particle of dry nitro-cotton or minute fragment of iron is unknown. The mark in the sheet of ballistite was as if made by a pin point. No one was killed or injured.

The second occurred at the same factory on March 20:—A sheet of ballistite "cracked" in rolling and was broken, but no damage was done. No one was killed or injured.

The third occurred at the same factory on May 13:—A small quantity of ballistite which was being rolled between steam heated rollers, took fire. No one was injured, and no damage was done.

The fourth occurred at the same factory on May 28:—About an ounce of ballistite exploded in an experimental screw-press, about a pound of finished ballistite being ignited by the explosion. No one was injured, and very trifling damage was done to the machine.

The fifth occurred at the same factory on June 21:—Breech-block

* It is not quite clear what is meant by "black powder," of which 4 tons were said to have been present in the fifth compartment. We conclude that it must have been black ballistite (*i. e.* ballistite treated with graphite), and not ordinary black gunpowder, which must certainly have exploded.

of sporting gun slightly cracked in experimenting with smokeless sporting powder. No one was injured. The accident was due to the detonation of the ballistite charge on firing with an ordinary percussion primer.—15 *Ann. Rept. H. M. Insp. Exp.* pp. 115–143; 1891.

In his "Novelties in the Explosives Industry and Blasting," *Ding. Poly. Journn.* 275, 111; 1890, Oscar Guttmann says since our last installment the problem of smoke-weak powders has undergone a more rapid development than has ever before been known in the history of explosive agents. The daily papers teem with surprising statements wherein powders of unlike characters are classed in one category, so that it is difficult even for an expert to determine precisely what is meant. Under these circumstances it is the province of a technical paper to give its readers an accurate and extended account of the subject, but unfortunately the restrictions in this instance are of such a nature that only a general picture of the fundamental principles can be given.

It is but a short time since the adoption of magazine and rapid-fire guns was a burning question, and in a certain sense it is yet an open one, but still the powers have equipped their armies with rifles of one-third less caliber than those formerly in use, in order that the already heavily burdened soldier may carry a greater number of rounds of ammunition. This change in caliber necessitated, from the outset, a change in the powder charge, for it was essential that the bullet should have an equal range. Next, as owing to the rapid fire but little time was allowed for aiming the piece, it became essential that the projectile should have a very flat trajectory. This pointed to the use of a very *brisant* powder; but as this would necessitate the use of a very strong piece to resist successfully the suddenly developed pressure, it was agreed that new powder must be less *brisant* and should develop its full power at the muzzle of the piece, giving a high initial velocity with a low pressure.

These conditions obtain equally for small arms as for great guns, but the further development for the two classes is different and the powder problem becomes unlike for the two. Hence, when speaking to-day of the smoke-weak powders we refer principally to the small-arm powder.

Although at the outset it was sought to satisfy these requirements by changes in the composition, method of treatment during manufacture, and in the form of the cartridge, a fresh difficulty was soon

encountered. Even before this "an atmosphere filled with powder smoke" had been no empty phrase, but with the rapid-fire guns it was found that the smoke would be increased so as to be insupportable, and that even the skirmisher would be so enveloped, after a few rounds, especially in calm weather, he would be unable to take aim. Hence a powder had to be invented which burned without smoke, and since this, while theoretically possible, was not so in practice, the powders of this class which appeared were first styled in Germany smoke-feeble powders (rauchschwaches Pulver).

From the preceding it appears that the smoke-feeble powder should satisfy the following requirements:

1. High power in a small space.
2. Low specific gravity (to produce a light cartridge).
3. Low gas pressure.
4. High initial velocity.
5. Great flatness of trajectory.
6. Small development of smoke.
7. Harmlessness of the smoke.
8. Constancy.
9. Safety in handling.

The eighth point demands a thorough discussion, for under "constancy" is to be understood a number of conditions.

We shall see later on that the smoke-weak powders principally belong to the class erroneously styled chemical explosives. The readiness with which such substances are resolved by explosion into their constituents throws a doubt on their constancy under all conditions, and their permanency must be proven under all the extremes of heat and cold, dampness and dryness, blows and shocks, agitation, exposure and the like, which obtain in practice. Again, the tendency, such as has been observed in the black powder, to separate into its constituents when moist must be provided against. No mildew should form upon them as does form on gun-cotton. They should have no action on the walls of the cartridge cases. They should be so insensitive to mechanical influences that they will withstand careless handling in the field.

In seeking for the ideal smoke-feeble powder it was but natural to turn to nitrocellulose. Already for many years wood nitrocellulose, known as Schultze powder, has been employed in England for sporting purposes, and this was followed by E. C. powder,* which

* Ding. Poly. Jour. **249**, 456; 1883.

consisted principally of gun-cotton; while more recently a number of other gun-cotton powders have been noticed, principally for use as sporting powders, but were introduced into use only with great difficulty, and the sporting-paper *Field* had frequently to recount accidents caused through the bursting of the pieces.

Owing to the increasing use of gun-cotton for filling torpedoes and shell, the process of manufacture has been so perfected as to yield an explosive whose properties can be maintained nearly uniform. At the same time, owing to melinite, attention has been called to picric acid and its derivatives, and these have been more thoroughly studied.

The use of gun-cotton proper (trinitrocellulose) could not be thought of, owing to the *brisant* action of this body, but it was found that collodion-wool (dinitrocellulose, soluble gun-cotton), which was less *brisant*, could be converted into a nearly homogeneous mass which satisfied many of the requirements of a smoke-feeble powder, but it was still so *brisant* when used alone as to produce too high gas pressures and too irregular initial velocities. Hence the more successful recent powders consist of soluble gun-cotton mixed with other substances which diminish the *brisant* effect, or it is treated in a particular manner to produce the same result. Thus Wolff & Co., in Walsrode, who have been treating gun-cotton for use in shell charges * in a similar manner, treat the collodion-wool with acetic ether, and the thin skin of collodion thus produced retards the rate of burning. A similar process is employed by H. S. Maxim, of London,† who conducts the vapor of acetic ether to the gun-cotton, and when action has taken place, forces the plastic mass through holes into strips, which are then cut into smaller pieces.

Fr. Gaens, in Hamburg (under which name some expect to find the powders produced by the Rottweil-Hamburg factory), dissolves nitrocellulose in acetic ether to form a gelatinous mass, and mixes with 25 parts of the nitrocellulose, 60 parts of potassium nitrate, and 15 parts of ammonium humate (obtained by treating peat with lye); the mixture being then pressed, granulated and dried.

The Nobel smoke-feeble powder ‡ was originally a modification of the camphorated blasting gelatine, but it was found that the camphor was unreliable and required a special purification to secure uniform results. At present, according to private information, this

* Proc. Nav. Inst. 11, 112; 1885. † Ding. P. J. 272, 66; 1889.
‡ Ding. P. J. 273, 67; 1889.

powder consists of 50 parts of nitroglycerine and 50 parts of collodion-wool. It is impossible to produce a gelatine containing so large an amount of nitrocellulose directly, so benzol, in the required proportions, is mixed with the nitroglycerine, and these are sprayed in fine streams on the nitrocellulose. The mixture, after evaporation of the benzol, is then rolled into sheets which are cut into strips and grains. The sheets have a dark brown color and resemble caoutchouc. The powder is more yellow-brown. If a sheet is ignited it burns in layers and emits sparks.

It is interesting to note that in the case of the Nobel powder, nitroglycerine, which is one of the most powerful explosives, is used mainly to diminish the *brisant* effect of the collodion-wool, and also that it does not detonate even under the influence of the primer of the rifle. The impediments which prevented the production of perfectly uniform gelatine are inherent in the manufacture of this powder, and this lack of reliability is no doubt the reason why this smoke-feeble powder, which otherwise possesses so many excellent qualities, has not come into use.

Abel and Dewar are reported to be engaged in perfecting the gelatinization process for the English government, and in manufacturing a powder which is said to have given excellent results. This new powder, called Cordite, is brown in color, and is in the form of cords of the length of the cartridge, which are bundled like fagots.

The Swiss government have already introduced a smokeless powder, P. C. 88 (Powder Composition 88), made by Schenker and Amsler Sohn, which gave with a charge of 2.4 grams in the 7.5 mm. Schmidt rifle an initial velocity of 615 m., with a maximum pressure of 1300 atmospheres.

France has for some time possessed the smokeless powder produced from collodion-wool by Vieille. Austro-Hungary seems recently to favor the powder of Major Schwab, which is described as a dark-gray, coarse-grained chemical product. Belgium is engaged in the production of wood-nitrocellulose. Germany, which has perhaps made the largest number of trials of private powders, is said to have declined to accept any powders produced by private firms, and to have recently rejected a large lot for failing to meet the requirements and for lack of sufficient stability. It is believed that Germany possesses in the powder manufactured by Major-Gen. Küster, at Spandau, an excellent shooting agent.

In general it may be said that no perfect smoke-feeble powder has

yet been invented, each of those known having its weak points, and therefore those governments that are not directly menaced are disposed to await further developments.

Picric acid and its congeners play an important role in cannon powder. It is yet too early to treat of this, because very sensible irregularities are observed in the composition for large charges, and up to the present nothing really good is at hand. In general, guncotton, ammonium picrate and fused picric acid are preferred for projecting and bursting charges.

Since the patents of the different factories seem to conflict, and the different smokeless powders have much in common, some of the German manufacturers have combined with Nobel, by which all are protected, and through their co-operation *one* satisfactory powder may be obtained.

In the *Journal of the Royal United Service Institution*, London, July, 1891, p. 707, is a paper by Lt. Col. G. V. Fosbery, in which, after referring to the historical development of the magazine gun, he continues as follows in regard to the ammunition which they carry: "Side by side with the change of weapons, a no less important one has been made in the ammunition they carry. That such should have been the case is but the logical consequence of the adoption of the repeater. From the moment this was decided on, it was seen that, in the first place, it would be desirable to reduce the size of the cartridge so as to maintain the handiness of the weapon; and, secondly, to reduce its weight in order that the soldier might carry a larger number—wrongly or rightly supposed to have become an absolute necessity.

"To reduce the *size* of the cartridge, the space occupied by the charge must be diminished, and for this either the present charge must be made to occupy a smaller space, or a more energetic explosive be found. We are thus at once compelled to use either compressed gunpowder, or one of the higher explosives.

"Again, to take largely from the weight, the bullet must be lightened; and here we must be careful. The range of artillery is increasing every day, and the bringing of quick-firing guns into the field is but a question of time. The infantry cannot afford to lose a yard of their range. The sectional density of the bullet cannot, therefore, be lowered—nay, rather needs increasing—and the reduction in weight must be effected by a diminution of caliber.

"Many of us were in hope that this would go no further than to 0.400 inch or 0.380 inch, when a plain hardened bullet could have been used, and a very considerable economy in the price of ammunition been effected. When, however, it came to be seen what velocities, range, and penetration could be got with a thing like this, no bigger than a common pencil-case, the caliber of 0.303 was decided on, and with it, as a consequence, the metal envelope, regarding the cost and other difficulties of which so much has been said. The studies of Hebeler and Guillaumôt, and the practical experiments of Lorentz prepared the way for this or even a greater reduction of caliber; so that, in theory, no risks of mistake were run.

"It may be an open question whether or no at extreme ranges the fire of the new magazine gun will be as fatal as is that of the Martini-Henry, and whether it would be possible with it to inflict on a distant enemy such terrible losses as fell upon the Russian columns in the valleys near Plevna from Turkish unaimed high-angle fire. We all know that a very small and light bullet, having a speed of 1600 feet per second or over, *i. e.* a bullet traveling at so-called *express* speed, will smash bones and tear up and pulverize flesh in a way totally different from the behavior of the same bullet endowed with a lower velocity, and it may prove to be the case that beyond certain ranges, the effects of the new projectile, say on supports and reserves, will be less than those of the heavy Martini bullet in a very notable degree. As, however, we are promised an initial velocity of something approaching 2000 feet per second, no doubt we shall have an extremely flat trajectory and deadly effects for a very considerable distance, and in any case what is true of our own bullet will—so nearly alike are they—be true of every other bullet in Europe.

"At present, so far as is known to me, we are still in search of the ideal explosive; one, in fact, which shall pack into the smallest possible space, develop the utmost energy, and keep indefinitely under all possible circumstances, and until we have found this, or at all events some reasonable approach to it, we cannot with a light heart adopt, as our Continental friends have done, a smokeless powder for the use of our troops. Gunpowder we know all about; it is a good honest mixture, and, sorely tried as it frequently is ashore and afloat, it may be always reckoned on to do its duty so long as we keep it dry. But when we come to high explosives—specially when these are chemical compounds, and from their very nature more or less unstable compounds at that—we, more than any other people, must

exercise the utmost precaution in their general adoption, and be sure that neither the damps and heats of India, the salt air in our naval magazines, nor the cold of Canadian winters, will set these treacherous substances fermenting, decomposing, or exploding. Hitherto perhaps on the whole Professor Abel's powder, cordite, has shown the best all-round qualities, and bids fair for final selection.

"Having thus spoken of the ammunition question, which will, I believe, when fully settled, effect a more marked change in the conditions of war than even the adoption of the magazine gun, I will, if you please, return to the question of the latter."

U. S. Letters Patent No. 456,508, July 21, 1891, have been granted Alfred Nobel for an Improved Celluloidal Explosive and Process of Making the Same.

It is known that the gelatinous compound commonly called "blasting gelatine," and patented by him in 1876, is composed of nitroglycerine and soluble nitrocellulose, the proportions adopted in practical use being from five to seven parts by weight of the nitrocellulose, to from ninety-three to ninety-seven parts of nitroglycerine, to which is added a small portion of nitro-benzol or analogous matter when it is desirable to make said jelly less sensitive to concussion or percussion. This compound, owing to its eminently detonative character, has been extensively used for blasting rock, but has proved altogether too violent in its action for use as a propeller for projectiles.

The object of the present invention is to so modify the explosive character of this compound as to produce from the same materials an essentially new article possessing the progressive explosiveness needed for propelling projectiles. This he effects by employing a process enabling him to incorporate with nitroglycerine a quantity of soluble nitrated cellulose 10 to 20 times greater than that which is contained in his "blasting gelatine," thereby producing a substance which, in its physical aspect as well as in its intrinsic explosive properties, differs widely from the "blasting gelatine," inasmuch as through the horny or celluloidal character which it assumes it is capable of being reduced to so-called "grains" akin to those of granulated gunpowder.

In manufacturing his present explosive, he dissolves in 100 parts, by weight, of nitroglycerine, say 10 to 15 parts, by weight, of camphor, adding thereto as a diluent, say 50 to 100 parts, by weight, of

benzol. To this mixture is added, say 100 parts by weight, of dried, pulped, carded, soluble, nitrated cellulose, such as nitrated cotton fiber. He then mixes the materials until the nitrocellulose has completely absorbed in its pores the aforesaid liquid and until homogeneity is secured. This done, the benzol is evaporated in the open air, or, better, in a closed chamber provided with a cooled condenser, for the purpose of recovering the benzol or the greater part thereof. When the benzol is evaporated, the material thus obtained is passed for malaxation between steam-heated rollers, when it assumes the aspect and consistence of a somewhat soft celluloid. It is then ready to be rolled out into sheets of any required thickness. These sheets he converts into "grains" by cutting them up into cubes or small pieces of any desired shape, which reduction serves the same purpose as granulation for gunpowder.

The addition of benzol, for which may be substituted any other volatile substance having the same property of mixing with nitroglycerine and rendering nitrocellulose insoluble therein, serves no other purpose than to facilitate by such insolubility the equal absorption and distribution of the liquid into the fibers of the nitrocellulose. As soon as the benzol has been evaporated the nitrocellulose begins to dissolve, and when dissolved the compound is treated as already described.

The given proportions of the ingredients are not absolute, but may be varied in a wide measure, the limits of which will be determined by the facility or resistance which the compound offers to its reduction into "grains." Thus if the celluloidal substance contains more that 2 parts of nitroglycerine to 1 part of nitrocellulose, it becomes almost too soft for a substance which has to be used in a granular form; and if it contains as little as 1 part of nitroglycerine to 2 parts of nitrocellulose, the celluloid obtained is more stiff and hard than needed, and is less easy to manufacture than such celluloid containing no more than half its weight of nitrocellulose.

When the celluloidal substance is made to contain more than half its weight of dissolved nitrated cotton fiber, its formation in the manner described becomes somewhat troublesome, in so far as it requires a prolonged malaxation between steam-heated rollers, or similar treatment. In such case he prefers the substitution for benzol of a volatile substance, such as acetate of amyl, or of ethyl or acetone, wherein the nitrocellulose is soluble, and wherewith the nitroglycerine is miscible, and he adds of such solvent the quantity

needed for complete incorporation of the ingredients; the proportion depending on the solvent's volatility and the temperature at which the malaxation is effected; but there is no mistaking in practice the proportion needed, since sufficient of the solvent must be added to obtain a translucent celluloidal substance. Moreover, for practical use the above given proportions of equal parts of nitrocellulose and nitroglycerine plus camphor gave an excellent result, so that the addition referred to of an excess of nitrocellulose, necessitating an extra addition of solvents, will be resorted to only in exceptional cases.

The nitrated ingredients used are to be deprived carefully of adhering acids by proper methods of washing.

Solid powdered substances may be kneaded in by malaxation between steam-heated rollers or otherwise, and the explosive celluloid may be mixed with pulverulent explosives, such as nitrated starch, nitrated dextrine, mealed gunpowder, or picrates; but it may also be mixed, and this is of importance with powdered oxidizers, such as nitrates or chlorates, for the purpose of furnishing the oxygen wanting for complete combustion, and with a view to reduce the cost price of the article.

The celluloidal explosive composed of 100 parts of nitroglycerine, 100 parts of nitrocellulose, and 15 parts of camphor, contains approximately the oxygen needed to convert, by explosive combustion, all its constituent hydrogen into water vapor and all its carbon into carbonic oxide; but to obtain complete combustion and thereby to convert said carbonic oxide into carbonic acid, it would be necessary to incorporate with each 100 parts of the compound about 82 parts of nitrate or chlorate of potash, or 69 parts of nitrate of soda, or 100 parts of nitrate of baryta, or 163 parts of nitrate of ammonia, or 96 parts of perchlorate of ammonia.

Bearing in mind that one part of hydrogen requires for its combustion eight parts of available oxygen, and that each six parts of carbon require for transformation into carbonic oxide eight parts, and for forming carbonic acid sixteen parts of available oxygen, it is easy to calculate the proportions of oxidizing nitrates or chlorates suitable for each particular case, it being understood that the quantity of oxidizers added should not exceed that needed for complete combustion. Also, the quantity of powdered oxidizers which can be added is limited by the capability of easy practical incorporation by malaxation. The more nitroglycerine and the less nitrocellulose it contains,

the more soft and plastic the explosive celluloid becomes, especially when heated, and the greater will be the proportion of powdered substances which can be practically incorporated.

The camphor or other predisposing solvent may be partly, and even almost entirely evaporated without very materially altering the explosive properties. Such evaporation can be effected by long exposure to the air at the ordinary temperature; but it is much quickened by letting a current of air heated to, say 50° C., percolate among the "grains" of the powder. Of course such evaporation reduces the amount of carbon and hydrogen, so that if oxidizing nitrates or chlorates be incorporated with the explosive, their quantity should be proportionately reduced.

This explosive celluloid can be used for blasting rock, in which case the "grains" may be compressed, similarly to gunpowder, so as to form cylinders or pellets suited for miners' use. Such compression may either be effected at a temperature (60° to 80° C.) at which the material becomes sticky, or at the ordinary temperature by slightly moistening the grains with a solvent, such as acetone or an acetic ether. Of course the grains should not be compressed so much as to leave no air space, upon which the quick spreading of the flame depends. The aforesaid powder can be fired without a detonator, thereby completely differing from the so-called "high explosives" now in use.

Whether for blasting or propelling purposes this explosive has always to be used in a granulated state, or so divided as to present a sufficiently large surface for combustion. The size of the grains or particles varies for each caliber of arms and other varied conditions, as is likewise the case with gunpowder; but otherwise the mode of using and firing does not materially differ from that explosive, except as regards suiting the charge to the ratio of power.

He claims:

1. A process for forming hard celluloidal explosives for propelling or filling projectiles, or for blasting purposes, which consists in uniting nitrocellulose and nitroglycerine, in proportions substantially as set forth, by means of a volatile solvent, as acetone, camphor, or the like, and subsequently removing said solvent, and mechanically treating the same, substantially as specified.

2. The hard, horny, or celluloidal explosive in granular form for above purposes, containing nitrocellulose and nitroglycerine, the same being so far solid at ordinary temperatures as to be susceptible of being cut up into so-called "grains."

3. The celluloidal explosive above described, in dense, horny, granular form, solid at ordinary temperatures, composed of nitro-cellulose, nitroglycerine, and suitable oxidants, as specified, and adapted for propelling or filling projectiles, or for blasting purposes.

The following "Experiments to Determine the Liability of Cordite to Explode *en masse*" were carried out on Woolwich marshes on the 21st of October, 1890, by the War Office Chemical Committee on Explosives, in the presence of the Director General of Ordnance Factories, H. M. Chief Inspector of Explosives, and other officers.

1. 100 lbs. of coarse cordite (3 in. diameter and 14 in. in length), packed in a service box (measuring 2 ft. 3 in. × 14 ft. 6 in. × 7 ft. 9 in. deep, and having 1¼ in. sides and 1 in. top and bottom), was attempted to be ignited by means of a tube and small priming charge of gun-cotton. But the cordite failed to ignite.

2. Repetition of above, but using a small priming charge of fine cordite (.05 in. diameter and 11 in. long). The whole mass burst immediately into flame, and burned with great and rapid energy and brilliancy. The lid was removed by the energy of the outburst, the screws being drawn, and those on one end bent. The mass burned for about three seconds, and the light was of the most brilliant character.

3. Repetition of No. 1, and with same result. No ignition.

4. Repetition of No. 2. The cordite ignited and burned with great brilliancy and a gush of bright flame for about 7½ seconds. The lid of the box was forced off (as in No. 2), and the screws were drawn, and in some cases bent.

5. A service case (of dimensions previously given) containing 100 lbs. of the fine cordite was surrounded by wood and shavings, which were set fire to. The bonfire burned for 15 minutes, when the cordite in the case ignited and burned, with a great rush of most brilliant flame, for about four or five seconds. Some small pieces of the burnt wood were then thrown to a distance of about 12 yards. An end of the box was forced out. One side was partially forced out.

6. Repetition of No. 5, but using fine instead of coarse cordite. After the bonfire had been burning for seven minutes the cordite caught and went off with a dull, muffled burst which nearly amounted to a mild explosion. There was, however, certainly nothing approaching a violent explosion, as was shown by only one side of the box being displaced.

7. Six service boxes containing each 100 lbs. of thick cordite were placed together, five on end and one on the top; the center box (in lower tier) was set fire to. It burned about six seconds, and upset the side boxes, but it did not throw off the top box; only the box which was ignited caught fire.

8. Five service boxes each containing 100 lbs. of thick cordite (*i. e.*, those which remained from the last experiment) were placed in a pile, two, two and one, breaking joint; and surrounded by wood and shavings, which were set fire to.

After	15	minutes,			1	box of cordite	ignited.
"	15	"	7	seconds,	1	"	"
"	15	"	14	"	1	"	"
"	15	"	21	"	1	"	"
"	15	"	28	"	1	"	"

Each box burned with a bright rush and burst of flame, but without explosion. The boxes were not broken up, and no fragments of the bonfire were projected beyond about 10 paces.

9. A pile of eight service boxes containing each about 75 lbs. (total 600 lbs.) of cordite was surrounded with wood and shavings, which were set fire to. The top box had a hole in it, which was roughly plugged, and this apparently caught fire and burned away non-explosively at 1 min. 10 secs. after the bonfire had been ignited. The other boxes ignited in succession and burned away non-explosively. The times were as follows:

	Min.	Secs.		Min.	Secs.
1st box,	1	10	5th box,	17	25
2d "	1	15	6th "	18	37
3d "	2	2	7th "	21	31
4th "	5	45	8th "	21	33

—15*th Ann. Rept. H. M. Insp. Exp.* p. 80, 1891.

C. Roth, Eng. Pat. 858, Jan. 16, 1890, for "Improvements in the Manufacture or Separation of Ammonium Nitrate and Sulphate or Chloride of Sodium and of Potassium," prepares ammonium nitrate from equivalent quantities of ammonium sulphate and potassium or sodium nitrate, either by heating the aqueous solution of these salts or by melting them at a temperature below that at which ammonium nitrate dissociates. If the aqueous solution be heated to a temperature above 110° C. until practically all the water is driven off (110° C.

being the temperature at which a solution of ammonium nitrate in an equal weight of water boils), or when the salts are heated in the absence of water and the melt maintained at a temperature between 160° and 200° C., sulphate of potassium or sodium, as the case may be, separates out in the solid form and settles to the bottom of the melt, whilst a liquid layer of ammonium nitrate remains above, which can be easily siphoned off or otherwise removed. A solution of ammonium in an equal weight of water, at a temperature of 110° C., is only capable of holding in solution 15 per cent of sodium sulphate and 10 per cent of potassium sulphate, and the solubility of these subtances in ammonium nitrate decreases as the temperature is raised, until at 200° C. (at about which temperature ammonium nitrate decomposes) only traces are held in solution. Ammonium chloride may be similarly used instead of ammonium sulphate, but its greater cost makes it less advantageous.

C. Roth and W. J. Orsman, Eng. Pat. 20,104, Dec. 13, 1889, for "Improvements in the Treatment or Preparation of Nitrate of Ammonium," proceed as follows: To prevent the absorption of hygroscopic moisture by ammonium nitrate, the crystals of that salt are dried by heating to 80° C., and a solution of nitrocellulose "in the various nitro- and chloro-nitro compounds of benzene or of the benzene series of hydrocarbons and their derivatives" is then poured over them, the mixture thoroughly stirred and allowed to cool. This treatment is especially advantageous when the ammonium nitrate is used in the manufacture of explosives.

To Paul Ward and Edward Mammatt Gregory have been granted U. S. Letters Patent No. 454,239, dated June 16, 1891, for the adaptation of a "Composition Suitable for Priming," to the purposes also of detonation, by the addition of a further ingredient to the composition, thus providing a novel, cheap, and effective detonating material, and manufactured at a minimum risk, suitable for use in any fuse or for similar purposes.

They form the chief basis of their explosive composition by the admixture of powdered coke, 2 pounds; amorphous phosphorus, 1 pound; pure chlorate of potash, 75 pounds, with the addition of benzol, chloride of carbon, or acetate of amyl. The amorphous phosphorus and chloride of potash are ground separately in a mortar or other vessel under one of the above fluids. The amor-

phous phosphorus is then submerged with either of the above fluids. Chlorate of potash is then added and the two ingredients are ground together under sufficient fluid to keep the mass from clogging. When this has been done for a suitable time, coke is added in powder and the whole is again ground for a short time. This forms an excellent priming composition, and by the addition thereto of paraffine or common tallow oil the powder will be enabled to cake together after the grinding fluids have evaporated. This reduces its sensitiveness to friction or percussion without detracting from its explosive violence or its sensitiveness to an electric current, and thus constitutes an excellent detonating composition.

They have found that the detonating effects of this compound are most pronounced when it is detonated by the previous explosion of a priming composition occurring at the closed end of a fuse and detonator-case, where the compression of the gases from the exploding priming composition causes intensely rapid combustion and consequent detonation in the detonating charge.

They state the manufacture, as described, to be much less dangerous than where the usual fulminate of mercury is employed, and that the addition of paraffine oil to the composition serves also to prevent oxidation of the ingredients when stored.

They claim a detonating composition consisting of powdered coke, amorphous phosphorus, chlorate of potash, and paraffine oil, substantially as and for the purpose set forth.

U. S. Letters Patent No. 455,332, July 7, 1891, have been granted Joseph A. Hunt, for a "Blast Cartridge." The invention is described as consisting of two parts of a cylinder, which are hollowed out in their middle so that when they are placed together a recess is formed for the reception of the explosive which may be used. These two parts have each in one end a perforation for the insertion of a fuse, and are made with longitudinal and abutting flanges, which, when the explosive is ignited, permit of the two parts flying apart in opposite directions, thus splitting the log, rock, or other analogous substance asunder. It is said that in using this cartridge no tamping is necessary, that a wet log can be split as easily as a dry one, and that this method of blasting is less dangerous than the old methods, in that the cartridge will not jump out of the log when fired. He claims as new the two halves of a cylinder, recessed as above described, each possessing longitudinal and abutting flanges, with a perforation at the end of each for insertion of a fuse.

Commander F. M. Barber, U. S. N., has been granted U. S. Patent 435,788, Sept. 2, 1890, for a "Method of Floating Stranded Vessels," in which, after pointing out that while one hundred pounds of gunpowder or thirty pounds of gun-cotton will infallibly blow a hole in the side of a ship with which it is in contact, yet at a distance of twenty-five feet horizontally, or ten feet vertically, a vessel using such a torpedo will, while receiving a heavy shock, remain entirely uninjured, he claims: The method of floating a stranded vessel or other object by exploding torpedoes or like agents beneath the surface of the water in the vicinity of the same, thereby causing a shock or concussion and at the same time exerting traction thereon, as by hawsers, from a point outside the vessel, substantially as described.

Under the title "Outbursts of Gas in Metalliferous Mines," B. H. Brough gives, in the *School of Mines Quarterly*, **12**, 13–22; 1890, an account of a number of cases in which gas has been liberated in metalliferous mines, and in some of which serious explosions have occurred. He shows that these outbursts of gas are not always due to the same cause, and he gives the following explanation to account for the formation of the gas in the various cases described: 1. The decomposition, in a mine, of timber in contact with water or moist air may produce fire-damp, which would accumulate in cavities that are ultimately broken into. 2. In iron mines when the iron is not entirely in the state of peroxide, water might be slowly decomposed and hydrogen produced. 3. Fire-damp may be liberated from beds beneath the ore-deposit and find its way through fissures into the workings, the gas being given off from rocks enclosing bitumen in the same way as the natural gas of the United States and other countries. At some of the Derbyshire mines the gas is derived from the Lovedale shales, which are of a bituminous character. 4. Fire-damp may be produced from the decomposition of organic matter in the same way as the hydrocarbon met with in salt mines. 5. In some cases explosions have been caused by outbursts of sulphuretted hydrogen produced by the action of acid waters on pyrites ore. 6. The outbursts of carbon dioxide met with at Foxdale, Freiberg, and Massa Maritima, may have been caused by the action of acid water, produced by the oxidation of pyrites, on limestones and other metalliferous carbonates.—*Jour. Soc. Chem. Ind.* **10**, 143; 1891.

An explosion, which in many of its features recalls those of Rochester and Pawtucket,* occurred in Providence, R. I., Sept. 5, 1891, and resulted in fatal injuries to one man, severe to two others, and slight injuries to several others. From the description in the *Prov. Journ.*, Sept. 6, 1891, we learn that private parties have a contract with the city for the disposal of its swill; that as a step in this process the grease is extracted with petroleum-naphtha; that this naphtha is brought once a month in tank cars holding 7000 gallons each; that this naphtha is conveyed from the cars, through a two-inch pipe, 500 feet long, to the works; that on the day of the accident a leak was discovered in the pipe leading from the naphtha tank by which naphtha escaped to the river, and that immediately on discovery the hole was plugged. It was not supposed that any considerable amount of naphtha had escaped, yet, within a few minutes after the hole was stopped, a report was heard from the Woonasquatucket river, and a sheet of flame, followed by a dense cloud of black smoke, was seen to be projected to a considerable height above it. It was found that a pile-driver had been at work in the river, and that the vapor from the naphtha floating by the scow had become ignited at the fire under the boiler.†

The *N. Y. Herald* of Oct. 16, 1891, details the circumstances attending an explosion on board the U. S. S. Atlanta, Oct. 13th, while at sea in a gale of wind, from which it appears that the forward collision compartment being found filled with water through a leak in the hawse-pipe and imperfect closing of the forward hatch, a handy billy was rigged to pump it out, and when after some hours the suction failed, an ordinary lantern was lowered into the compartment to ascertain the cause, whereupon an explosion ensued which resulted in severe injuries through burns to two men, and more or less serious ones to four others, while the collision bulkhead was markedly bulged. A board ordered, of which the writer was a member, found that the collision compartment had been used as a store-room for paint stores in their original packages, and that among them were spar and damar varnishes and Japan dryer, each of which gave off vapors at ordinary temperatures, which formed easily exploded mixtures when diffused through the air, and that this mixing was more readily effected by agitation with salt water under the conditions which prevailed on the Atlanta.

* Proc. Nav. Inst. 14, 165–166; 1888. † Ibid. 20, 291; 1889.

The explosion and fire which occurred June 15, 1891, in compartment No. 73 of the U. S. S. Philadelphia, were traced to a similar source, and the analogy to the Doterel* accident and similar ones pointed out. (*N. Y. Tribune*, Nov. 27, 1891.)

In consequence of this report, the *Brooklyn Union* of Nov. 11, 1891, states that the Secretary of the Navy has issued an order amending paragraph 34 of page 39 of the Regulations of the Navy to read as follows:

"Spirits of turpentine, alcohol, all varnishes and liquid dryers must be kept in metallic tanks or vessels securely stowed away on the spar deck, and they are never to be taken below except in small quantities for immediate use."

According to the *N. Y. World*, Oct. 27, 1891, an explosion of a similar nature occurred at No. 69 Pineapple street, Brooklyn, N. Y., Oct. 26, through which a young girl was seriously, and perhaps fatally burned. It has been found that petroleum-naphtha or benzoline is a most efficient agent for the destruction of moths, and it is a not infrequent occurrence in establishments where furniture is treated, that, since the fabric is not affected by the naphtha, lounges, mattresses, arm-chairs and the like are completely immersed in the liquid, and retained until saturated.

In this instance the upholsterer employed sought to destroy moths which had gotten into the furniture, and to arrest and repair their ravages, but he endeavored to do this by sprinkling the furniture with naphtha, and closing the doors and windows of the room in the dwelling-house in which the articles were. Some time later the child returning from school opened the door between the room with the naphtha-laden atmosphere, and an adjacent one in which a fire was burning in a stove, when the vapor at once ignited and flashed back.

In the *Sci. Am. Sup.* **32**, 13053; 1891, under the title of the Spontaneous Ignition of Carbon Bisulphide, Dr. Max Popel states that in view of the widespread application of carbon bisulphide in extraction processes, and of the frequent explosions and fires which are caused by its spontaneous ignition—*i. e.*, without its actually coming in contact with flame or any red-hot substance—it is of interest to collect and publish all the observations which have been made concerning the causes of such accidents.

* Proc. Nav. Inst. **8**, 313; 459; 671; 1882.

Unfortunately, the nature of carbon bisulphide is by no means thoroughly known; in particular we have no complete data as to its behavior at different temperatures and pressures, mixed with other gases, air, etc., in contact with metals and other substances; and yet a knowledge of these very points is necessary before the substance can be employed with safety. The main difficulty to be met with in the employment of carbon bisulphide is its volatility. Even at a very low pressure (0.1 atmosphere and less) it is quite impossible in an extraction apparatus to prevent its escape by means of taps and the like. Again, the air which is always admitted on filling the apparatus is again drawn out, saturated with the vapor, the loss increasing with the temperature. In the course of some experiments instituted to ascertain the actual amount of material carried away by the air, a spontaneous ignition of carbon bisulphide was observed under the following circumstances: The tube which connected the interior of the apparatus with the air, and which had previously ended near the roof of the building, was bent over and the end allowed to dip about 10 centimeters into a vessel filled with oil. It was found that the oil absorbed the carbon bisulphide almost completely, and that the whole loss, at the temperature of the cooling surface (10°–12° C.), was only very small; but that it amounted to several liters in the course of a very few hours at a temperature of 8°–10° above this. A pressure of about one-eighth of an atmosphere was also set up in the apparatus, owing to the descending path which the air had to take, and to the pressure of the oil, and this, of course, affected the boiling of the carbon bisulphide. In order to remedy this, the apparatus was to be removed and replaced by another arrangement. While a workman on the roof was screwing off the descending arm of the pipe, Dr. Popel stood by the oil flask, which was perfectly cold, as was also the pipe dipping with it, and in order to allow a little more room for the motion of the pipe, he placed the flask at a lower level, when just at that moment the workman informed him that the pipe was beginning to get very hot at the joint. He was about to quit the place and see for himself if this were correct, when an explosion took place in the apparatus, and the oil saturated with the carbon bisulphide took fire. In this case, therefore, the spot at which the ignition started could be determined with a certainty which is rare in accidents of the kind. No external influences were possible, and the idea that the explosion was caused by the absorption of oxygen by the oil and consequent heating is disproved by the fact that the whole remained

quite cool until the actual moment of ignition. The only probable explanation is that the mixture of carbon bisulphide and air was raised to its igniting point by the heat developed in the pipe by the friction at the bend which was being unscrewed. The pressure being diminished by the lowering of the vessel, the flame spread downward and ignited the oil. The actual temperature attained in this case could not be ascertained, but the following experiment shows that carbon bisulphide and air will ignite even below the boiling point of water. A watch-glass containing carbon bisulphide was placed in a new copper oven with smooth walls; explosion took place regularly at 96°–98°; when the walls were covered with a layer of clay this no longer occurred, so that copper seems to have played an important part in the phenomenon. Mixtures of carbon bisulphide and air readily ignite when brought in contact with iron pipes through which steam at 3 to 4 atmospheres (135°–145° C.) is passing. The less carbon bisulphide there is in the mixture the higher is its ignition point and the sharper the explosion.

It is, therefore, necessary, in places where this substance is employed, to cover all steam pipes, cocks and valves with great care, and also to work without any pressure, so as to avoid loss. Unfortunately it is impossible to employ the vacuum, since the escape of the vapor into the pump cannot be avoided, and explosions would be caused by compressing it when mixed with air.—*Chem. Zeit.*

T. E. Thorpe describes in *J. Chem. Soc.* 55, 220–523; 1889, a lecture experiment on the "Decomposition of Carbon Disulphide by Shock." The apparatus consists of a thick glass tube about 600 mm. long and 15 mm. wide, fitted at one end with a caoutchouc cork, through which pass two stout wires or thin rods. A small brass or iron cup, like a deflagrating spoon, is attached to one wire, and the other wire is bent so as to come within 2 to 3 mm. of the bottom of the cup. About 0.05 gram of mercury fulminate is placed in the cup, the cork is fixed tightly into the tube, which is clamped to a retort-stand and tilted to an angle of 45°; and a piece of paper which is slightly longer than the tube, and which is moistened with carbon disulphide, is placed within the tube, where it remains for a minute or so, when, the tube being practically filled with the vapor of carbon bisulphide, it may be withdrawn. On now passing a spark from a Ruhmkorff coil through the cup, the fulminate will be detonated and will detonate the disulphide, and the internal walls of the tube will become lined with a deposit of soot mixed with mercuric sulphide and

free sulphur. Similar effects are obtained by filling the tube with a mixture of carbon disulphide vapor and nitrogen or carbon dioxide, but in these cases the deposit of carbon is comparatively dense, lustrous and coherent. This forms an easy and safe method for demonstrating the resolution of an endothermic compound by shock.

Dr. Thorpe was led to devise this experiment through an observation made while investigating the sulphides of carbon. Löw had obtained the C_2S_3 by the action of sodium amalgam on CS_2, and Raab had obtained C_5S_2 by the action of sodium alone on CS_2. Dr. Thorpe used the fluid alloy of sodium and potassium, and treated rectified, dehydrated CS_2 with this alloy, when, after a few hours' standing, the alloy was seen to be incrusted with a yellowish-brown powder. On now shaking the bottle to detach the crust, the contents exploded with a loud report, and the operator's hand was coated with a black deposit consisting, apparently, of finely divided carbon. Further experiments showed that the yellowish-brown powder was highly explosive, and that on simply pressing with a glass rod it detonated with even more violence than nitrogen iodide.

He is as yet only able to offer conjectures as to the nature of this powder. It may be a compound of carbon monosulphide and potassium, analogous to that formed by carbon monoxide and potassium.* There is some ground for the belief that the highly explosive character of the latter substance is really due to the formation of potassium acetylide, produced by the action of moist air upon it, for it is well known that when thrown into water it detonates with great violence and with the evolution of acetylene. In the case of the compound formed by the action of carbon disulphide there can, however, be no suspicion of the presence of hydrogen.

Attempts were made to effect the decomposition of the CS_2 by the use of other explosive agents than the yellowish-brown powder and the fulminates, gunpowder, potassium chlorate and phosphorus, potassium chlorate and ammonium picrate, copper acetylide, nitrogen iodide, Berthollet's silver amine, oxygen and hydrogen, and oxygen and carbon disulphide vapor being used, but they had no apparent effect.

In an article on the "Formation and Decomposition of Carbon Disulphide," *Compt. rend.*† 67, 1251; 1869, Berthelot calls attention

* Proc. Nav. Inst. 12, 190–193; 1886.

† Bull. soc. chim. 11, 45; 1869. Chem. Centr. 333; 1869. Wagner Jahr. 15, 172–174; 1869.

to the fact that Favre and Silbermann obtained 258.5 cal. as the heat of combustion of the molugrams of CS_2, while the same weight of C and S gave only 24.5 cal., yet at a temperature sufficiently high to decompose the CS_2 no explosion took place. In his *Sur la Force des Matières Explosives* **1**, 196; 1883, he gives the heat of formation of CS_2 as —0.55 cal. for the gaseous and —7.2 for the liquid state, and in **2**, 149; 1883, he states that he has detonated the endothermic gases by means of mercury fulminate.

Under the rather inept title, "The Direction taken by Explosives," Charles E. Munroe combats, in the *Illustrated American* **3**, 286; 1890, the popular notion that "high explosives explode downwards while gunpowder explodes upwards," and illustrates his argument by photographs of results obtained in practice. One of the most important illustrations unfortunately is presented in the reversed position.

We are indebted to the courtesy of Major J. P. Cundill, R. A., for a copy of the "Addenda to Dictionary of Explosives,"* bearing date of 1890, which brings the literature of the subject as treated in his very valuable work up to date.

M. Eissler, whose "Modern High Explosives" is so favorably known in this country, has published a "Handbook of Modern Explosives,"† which is in many particulars a better book, as it covers more ground and contains fresher data. We understand that owing to existing copyright there are some obstacles to the introduction of the work into this country.

Vivian B. Lewes, "Service Chemistry,"‡ prepared by the Professor of Chemistry at the Royal Naval College especially for the instruction of naval and military men, gives a very clear exposition of the subject of explosives as regarded from a chemical standpoint.

Through the courtesy of M. P. F. Chalon we are in receipt of his "Note sur les Poudres sans Fumée,"|| which gives an admirable presentation of this subject up to the date of publication.

* W. & J. Mackay & Co., Chatham, Kent, pph. 17 pp.

† Crosby, Lockwood & Son, London, 1890, 8vo, 318 pp., 105 ill.

‡ W. B. Whittingham & Co., London, 1890, 8vo, 521 pp., 56 ill.

|| Publications du Journal Le Génie Civil, Paris, pph. 15 pp., 1890.

"Smokeless Powder and its Influence on Gun Construction,"* by J. A. Longridge, presents the results of the investigation by a well-known ordnance expert of the data available for smokeless powders by the use of Sarrau's formulas. His conclusions are that smokeless powder has ballistic properties far superior to the old powders; that the erosive action on the guns will probably be less; that its use in existing guns of the new forged steel type will not lead to any considerable increase of ballistic effect *without considerable risk*, owing to the increase of pressure developed in the front part of the chase, although the actual maximum pressure on the gun may be less; that to utilize the high ballistic powers of the new powders very strong guns will be required, and that such guns will have to be much stronger *in front of the trunnions* than those of the new type forged steel guns: that to arrive at very high ballistic results it is not necessary to have guns of inordinate length, but by the adoption of higher initial, instead of low and more uniform pressures, velocities of 3000 feet per second and upwards are attainable with perfect safety. This points, in his opinion, to the wire system of construction, and he urges that immediate experiments be made to enable new ballistic formulas to be constructed, and determinations made of the tensile strain on the chase caused by the friction of the products of combustion.

B. Westermann announces "Methode zur Zerstörung von Felsen in Flüssenmittels aufgelegter Sprengladungen," by Johann Lauer.

Charles E. Munroe has in press Part II. of his "Index to the Literature of Explosives," in which the periodicals indexed in the first part are brought up to 1890; and in addition Dingler's Polytechnisches Journal, Proc. American Chemical Soc., Nicholson Jour., Edinburgh Jour. Sci., and Popular Science Monthly are indexed from date of first issue up to 1890, making in all 843 volumes which have been reviewed.

* E. & F. N. Spon, London, pph. 49 pp., 1890.

PROFESSIONAL NOTES.

DRAINAGE SYSTEM OF U. S. S. MONTEREY.

By A. W. STAHL, Assist. Naval Constructor, U. S. Navy.

The water-tight subdivision which is a prominent feature of all our new naval vessels involves, as a necessary consequence, a more or less elaborate pumping system for the purpose of removing water that may from any cause enter any of the separate compartments. It is not expected that any such pumping or, as it is usually called, drainage system will successfully cope against the volume of water that would be admitted through a large opening in the bottom or side of an unsubdivided vessel. But if the leak be slight, or if the water entering the bilges be that which is used to keep the crankpins or other parts of the machinery from heating, or that due to leakage of boilers, leakage of shaft tubes, or to any other of the many minor causes which exist in every ship, then the drainage system should be able to keep the vessel reasonably clear. In case of serious damage it is the function of water-tight subdivision to localize the effect of such damage and to set a limit to the volume of water that can enter the vessel. As soon as temporary or permanent repairs to the hull have been made, sufficient to prevent the further influx of water, that which has entered is to be pumped out.

Again, in some vessels, such as the Monterey, special arrangements are made for filling the double-bottom compartments with sufficient water to decrease the freeboard in action; and this large volume of water must be pumped out, if need be, with certainty and rapidity. A proper drainage system must then be able to clear any one of the many compartments into which modern ships are divided, and its manipulation and operation should not be interfered with by the fact of there being considerable water in the vessel. While the drainage system thus plays a necessary and important part in all naval vessels, it becomes specially important in vessels of the Monitor type. In such ships the small freeboard restricts the reserve of buoyancy to such an extent as to make it essential that all means provided for clearing the ship of water shall be of the most efficient character. In time of actual emergency the simplicity of such a system plays an important part in regulating its efficiency. A system which might work admirably on ordinary occasions might readily fail by reason of its complexity when the men detailed to operate it were excited by the danger due to the actual occurrence of some serious accident. It must also be borne in mind that in designing any such system, the weights of piping, valves, etc., must be kept within reasonable limits. The general arrangement of water-tight compartments and drainage of same adopted for U. S. S. Monterey, while not free from objections, yet seems to combine the elements of lightness, simplicity and efficiency to such an extent that a brief description of the same may prove interesting to officers of our service.

The Monterey, now nearing completion at the Union Iron Works, San Francisco, is a vessel of the Monitor type. She is 256 feet long, 59 feet beam, 17 feet in depth from bottom of keel to top of main deck at side. Her normal draft is estimated to be 14 feet 6 inches, so that her reserve of buoyancy is

that due to a possible increase of draft of 2 feet 6 inches. She has 83 transverse frames, her inner bottom extending longitudinally from frame No. 5 to frame No. 77, and transversely to the armor shelf or upper longitudinal on both sides. The transverse frames within the limits of the double bottom consist of main angles riveted to the outside plating, reverse angles riveted to the inner bottom plating, and vertical floor plates connecting and riveted to main and reverse angles.

There are six longitudinals on each side of the vertical keel, consisting, like the latter, of a continuous series of plates connected to inner and outer bottom platings by means of long angles. The transverse frames and the longitudinals are firmly united at their intersections by means of angle clips.

Every third or fourth transverse frame and every alternate longitudinal are made solid and water-tight in their connection with each other as well as with the inner and outer bottom platings; the plates of the remaining frames and longitudinals are provided with large lightening holes.

The space between the inner and outer bottoms is thus subdivided into 107 separate water-tight compartments, the actual water-tightness of which has been determined by filling each compartment separately with water under the maximum head that it could have while the ship was still afloat.

Above the double bottom we find a central longitudinal bulkhead, also two longitudinal coal-bunkers and two wing-passage bulkheads. There are also quite a number of transverse bulkheads, and by the intersection of these bulkheads this space is divided into 78 separate water-tight compartments. The fore and after peaks are similarly divided into eight compartments.

Access to the compartments in the double bottom is provided for by means of 99 manholes in the inner bottom plating, and 70 manholes in the water-tight longitudinals, all such manholes being fitted with hinged water-tight covers.

Communication between the other compartments above the double bottom and in the peaks is effected by 11 manholes and 73 water-tight doors, some of the latter being sliding and arranged to be operated from the berth deck, while others are hinged and can only be operated at the door itself.

We have thus a total of 193 separate water-tight compartments, each of which is to be so arranged and connected that it may be pumped clear of water.

The drainage system of this vessel is divided into two main parts: (1) The main drainage system which deals with all the water that is to be pumped from compartments above the inner bottom; (2) The secondary drainage system for pumping out the compartments between the inner and outer bottoms. The principal pipes of both systems extend practically the whole length of the ship, being located within the double bottom and close to the vertical keel, the 11-inch main drain-pipe on starboard side and the 4-inch secondary drain-pipe on port side. At intervals along the main drain-pipe are located five large non-return and stop-valves, each valve being secured by its flanges to the two sections of main pipe between which it lies. Each valve is also secured to the inner bottom plating, a large hole being cut in the latter to correspond to an opening in the top of the valve. These openings are provided with strainers, and it is through them that any free water above the inner bottom finds its way into the main drain-pipe. Certain of the various bulkheads above the double bottom are provided at their lower ends with sluice-gates which are operated from the berth deck, and by means of which any water accumulating beyond them may be sent to the nearest strainer leading to one of the non-return valves.

Along the engine and boiler rooms a short section of 11-inch main drain-pipe also runs along port side of vertical keel, being provided with two non-return valves, so that no arrangement need be made for allowing water to pass through the center longitudinal bulkhead. All the main drain-piping empties into two large wells, one in each engine room, built between the inner and outer bottoms, pipes leading from these wells direct to main steam-pumps and also to the circulating pumps belonging to the main engines.

Between each two consecutive water-tight transverse frames in or near central part of vessel there are six separate water-tight compartments within the double bottom, three on each side of keel, this number being slightly reduced at the very ends of the double bottom. Alongside the vertical keel and at the lowest point of every such section of six compartments is located a strainer box, which is connected by a branch pipe to the secondary drain-pipe running close by. In this branch pipe is a common stop-valve, arranged to be operated from the berth deck, so that each strainer can be pumped from independently. A sluice-gate, also operated from berth deck, is fitted to the vertical keel and to each water-tight longitudinal within each section, so that water from any of the six compartments in the section may drain down to the strainer box. Thus the water from all the compartments of each section is handled by one branch pipe. The secondary drain-pipe is connected directly with two steam-pumps and four hand deck-pumps; but means are also provided for connecting the secondary and main drain-pipes at three points, so that the secondary drainage water may enter the main drain-wells and be pumped out thence by the four steam-pumps connected therewith, and conversely the four hand-pumps can thus be used to assist in pumping from the main drain-pipe. The drainage from the crank pits ordinarily empties by a small special drain-pipe directly into the main wells; but when much oil is being used the crank-pit drainage may be pumped out separately by two small steam-pumps arranged for that purpose.

Sounding tubes are fitted to every compartment, so that the amount of water therein may be at any time ascertained from berth deck. It is to be noticed that the moving of all valves, sluice-gates, etc., and all other operations connected with the drainage are performed at the level of the berth deck, so that the presence of water in or above the double bottom does not interfere with the efficiency of the pumping system. The upper ends of all the rods coming to berth deck are provided with deck sockets, which automatically indicate at all times whether the valves, gates, etc., are open or closed. All pipes make water-tight joints with the water-tight plating through which they pass, and are provided with expansion joints between each two of such water-tight joints.

In the Monterey it was essential to keep the weight of piping, etc., down to the smallest practicable amount, and in view of this fact the system actually adopted and just described seems to combine the various factors of efficiency to a very considerable degree.

THE KURO-SIWO OR CURRENT OF JAPAN.

By J. J. MAHLMANN, Harbor Master of Kobe, Japan.

(Translated from Annalen der Hydrographie und Maritimen Meteorologie, by H. G. Dresel, Ensign, U. S. Navy.)

It is generally known that the Kuro-Siwo (black current) has its origin in the equatorial current of the Pacific Ocean. The latter, in reaching the Philippine Islands and islands immediately to the southward of these, breaks up into two branches, of which one turns towards the south along the Australian coast and towards the east. The other branch, called Kuro-Siwo farther to the north, sets towards the northward, passing along the east coasts of the Philippine and Loo Choo Islands, after which it takes a northeast direction, passing along the south and southeast coasts of Japan, continuing its course to the west coast of America. Having its origin in the equatorial stream, the temperature of the Kuro-Siwo is considerably higher than that of the ocean through which it flows. Its limits can therefore be ascertained by temperature measurements. The boundaries, breadth and rate of the current, however, are not constant, being

greatly influenced by the monsoons of the China Sea. The storms in the Pacific also exert a considerable influence on the Kuro-Siwo, frequently causing very marked changes in its direction. During fair weather the Kuro-Siwo runs in a nearly straight line from Van Diemens Straits to Rock Island, touching Osima on the way. During the winter months the current is seldom met with on this line, nor even at some distance to the southward of it, but in the summer during fair weather it can be surely depended upon, with the line from Osima to Rock Island as its northern limit. It is easily distinguished by the presence of seaweed, drift-wood, tide-rips, as well as by the dark color of the current (from which the name Kuro-Siwo) which contrasts vividly with the color of the surrounding sea. From Rock Island the Kuro-Siwo takes a more northerly direction, passes by Nosima Saki, and turns into the northern part of the Pacific Ocean.

For the most part no currents are met with in the waters adjacent to the northern limits of the Kuro-Siwo, but a counter current has been at times observed, as was the case in February, 1879, at which time the sailing ship Sumanura-maru, Captain Spiegelthal, which had lost her masts when distant about 10 sea miles from Osima, drifted 25 sea miles to the west in four days during a dead calm.

The width of the zone lying between the Kuro-Siwo and the coast of Japan varies with the direction and force of the wind. With heavy northern blows it increases ; with southerly and easterly blows it decreases. Should the latter winds be of considerable force and long duration, the Kuro-Siwo departs from its regular ENE direction and sets more or less directly towards the coast, where it causes unusually high flood-tides. As under these circumstances the current sets on shore with an appreciably high rate, it has been observed that steamers have been carried 16 sea miles towards the shore in as many hours, so as to make Osima on the port hand instead of on the starboard.

As the south and east winds are generally accompanied by thick weather, the greatest possible vigilance is necessary on passages between Osima and Rock Island. Neglect of this may easily lead to the loss of the vessel, as is shown by the loss of the French mail steamer Nile with nearly every soul on board, on the coast of Idsu. In fair weather vessels have seldom been set on shore by the current.

The zone along the coast in which the local tidal currents occur does not have the same width at all places or at all times. It extends seaward for 5 or 6 miles, and at the capes and promontories its width is only half a mile. As a rule, the velocity of these tidal currents varies inversely as the breadth of the zone ; the smaller the width the greater is the rate of the current. At times the flood-tide has not occurred at Osima, probably because the Kuro-Siwo in striking this cape sets directly across the path of the flood, or because at this time the flood sets through the channel between Osima and the main island.

The flood-tide runs along the coast in a westerly direction and enters the deep bays along their west shores, while the ebb sets out along their east shores.

While running along the coast between Osima and Rock Island, one should try as often as possible to discover whether the vessel is being set on shore, especially with northerly and easterly winds and falling barometer. On the passage from Yokohama to Kobe, in case the weather permits it to be done, the course after passing Rock Island should be laid near enough to the coast so as to skirt the boundaries of the zone of tidal currents. The danger of being set on shore is thus avoided, and the advantage obtained of being able to fix the vessel's position before the weather becomes thick. The distance of the course along the coast line varies but slightly from the distance corresponding to the direct course. The former course approaches the great circle arc between Rock Island and Osima.

In case the inshore course cannot be made, one should steer from Rock Island so as to make Matoya Light. Bearings of the latter will show whether

the vessel is being set ashore. If the weather becomes thick, after sighting Matoya, there is no longer any danger of being set on shore, as the distance from Matoya to Osima is short. As soon as Matoya Light is made, which is visible at a distance of 16 miles, the course must be laid so as to clear Osima.

THE ARMOR TESTS.

[*Iron Age*, December 10, 1891.]

VERDICT OF THE ARMOR BOARD.

After careful consideration of the results of the firing upon the six plates, it is the unanimous decision of the Board that they be placed in the following order of merit, viz :

1. The high-carbon nickel steel Harvey plate furnished by the Bethlehem Iron Company.
2. The high-carbon nickel steel plate furnished by the Bethlehem Iron Company.
3. The high-carbon nickel steel plate furnished by Carnegie, Phipps & Co.
4. The low-carbon nickel steel Harvey plate furnished by Carnegie, Phipps & Co.
5. The low-carbon nickel steel plate furnished by Carnegie, Phipps & Co.
6. The low-carbon steel Harvey plate furnished by the Bethlehem Iron Company.

The right side of Plate No. 1 showed very remarkable qualities. The two projectiles which struck that side penetrated not more than seven inches, the head remaining in the plate, completely filling the hole and with the appearance of having been welded to the surrounding metal, while the body was shattered into many fragments.

No cracks were made on that side of the plate.

The back of the plate on that side showed no disturbance except a hardly noticeable swelling on the surface.

It is to be noted that the upper part of plate No. 6 (Harveyed) showed qualities resembling those of the right side of No. 1, while, on the other hand, Plate No. 4 (likewise Harveyed) was totally lacking in such characteristics.*

Plate No. 2 showed a great degree of uniformity as well as resistance to penetration.

The small penetration of the 8-inch shot in Plate No. 3 is, in the opinion of the Board, due to the excessive upsetting of the projectile.

All of the armor plates were more or less cracked through, but only two, Nos. 3 and 6, badly, and these two plates alone showed cracking before the fifth shot. Plates Nos. 1, 2 and 3 kept out all the projectiles; No. 4 was perforated by one, and Nos. 5 and 6 by two projectiles each.

It will be noticed that the "high-carbon" plates show better results than those of "low-carbon," but it is believed that the chemical analyses of the plates now in progress will show that the words "high" and "low," employed by the manufacturers, have been used arbitrarily and have but little value for purposes of comparison.

The Holtzer and Firminy projectiles were part of the lot used at the Annapolis armor trials of last year.

Comparing the plates of this trial with the Creusot steel and the Creusot nickel steel plates of the Annapolis trials of September, 1890, the Board is of the unanimous opinion that—

No. 1, the high-carbon nickel steel Harvey plate furnished by the Bethlehem Iron Company, and No. 2, the high-carbon nickel steel plate furnished by the

* The method of tempering at Bethlehem differed from that at Pittsburgh.—Note by Departmental authority.

Bethlehem Iron Company, are superior to the Creusot steel and nickel steel plates of last year.

In this connection it should be considered that the firing at this year's trial was more rapid than at last year's, and that the interval between the fourth and fifth shots at each plate was about two hours instead of four days, as then. At this trial the plates were still "singing" from the blows of the 6-inch when they were struck by the 8-inch projectiles.

The Board will, in obedience to the Department's order, make a supplemental report upon a "high-carbon nickel steel Harvey" plate, and a "low-carbon steel Harvey" plate, to be furnished by Carnegie, Phipps & Co., which will be tried as soon as ready under the same conditions as the six plates whose trial has been completed.

OPINION OF THE SECRETARY OF THE NAVY

is summarized as follows:

"By far the most momentous question which the Department has had to consider in connection with the construction of the new navy is that of armor: 1. to secure a supply of American manufacture, and, 2. to determine what kind of armor should be adopted, having reference both to its composition and mode of treatment.

The experiments made last year at Annapolis, described in the annual report for 1890, consisted of a test of the two principal foreign types of armor, the English compound plate and the French all-steel plate, and an entirely new plate, also made in France, upon the special order of the Department, of nickel steel. The result of the trial showed that the compound plate was decidedly inferior, and that as between nickel steel and all-steel the former had distinct and positive advantages, the all-steel plate being broken into four pieces while the nickel plate remained absolutely uncracked.

A series of tests made during the following spring and summer confirmed the conclusions formed at the Annapolis trial as to the superiority of nickel steel, and the Department accordingly decided to adopt it and made arrangements with the contractors looking to that end.

It remained, however, to give a thorough trial to the first armor of domestic manufacture before beginning to place it upon vessels, and for this purpose it was decided to order typical plates, which should be made the subject of an experimental test. This trial was to ascertain two points: 1. whether our domestic manufacturers could produce an armor that would stand competition with the material manufactured abroad, and, 2. which of the various modes of treatment suggested would give the best results. In reference to the latter point the questions to be considered were the relative merits of rolling and forging in the manufacture, and the effect of a new method of treatment, named, from its inventor, the Harvey process, designed to harden the surface of the plate while retaining the toughness of its body.

Of the six plates tried, three were furnished by the Bethlehem Iron Company and three by Carnegie, Phipps & Co.

In these trials, which took place at Indian Head on October 31 and November 14, the plates were subjected to tests more severe than had ever been applied to any foreign government trials. Four shots were fired at each plate from a 6-inch gun with an impact velocity of 2075 feet per second, and an energy of 2988 foot-tons, using the Holtzer projectile of 100 pounds. One shot was then fired at the center of each plate from an 8-inch gun, with an impact energy of 4988 foot-tons, using Firminy and Carpenter projectiles of 210 and 250 pounds weight, respectively. The plates were placed normal to the line of fire.

The results of the trial were in the highest degree satisfactory. Each of the six plates manufactured in this country was superior to the English compound plate, while the nickel Harveyed plate and the high-carbon nickel plate were

superior to all the foreign plates of the Annapolis trial. They may, therefore, be pronounced in advance of the best armor hitherto manufactured in Europe.

Further light was thrown upon the question of the relative merits of all-steel and nickel-steel armor, and any doubt which may have remained upon that subject was finally set at rest. Of the three plates made by Bethlehem two were of nickel steel, one treated by the Harvey process, the other not, and the third was of all steel, Harveyed. Both the nickel plates proved to be far superior to the all-steel Harveyed plate, notwithstanding the advantages which it may have derived from the special treatment, and both proved superior to the French all-steel plate tried at Annapolis.

A third nickel plate, manufactured by Carnegie, under the rolling process, also showed a marked superiority over the all-steel plate of this year, and both it and the corresponding Bethlehem plate manufactured under the hammer showed a capacity of resistance to perforation fully 10 per cent greater han that of the French all-steel plate. In this respect the results furnished by the two American plates manufactured by the different processes (forging and rolling) proved to be remarkably uniform, the 6-inch shots that were fired at them differing in penetration but an inappreciable amount.

The trial thus definitely establishes the fact that armor of excellent quality may be produced by the rolling process, and that forging by means of the hammer, the greatest source hitherto of expense in manufacture, is no longer to be regarded as an absolute necessity. The importance of this fact can hardly be overestimated, for it raises a probability that within a year or two the armor-producing capacity of the United States may be quadrupled in case of necessity, and that if we had 10,000 tons to let and could give 18 months from date of contract to commence delivery, the cost of manufacture would be reduced from 25 to 33 per cent, while the work hitherto confined to two firms would be thrown open to a large number of competitors.

Finally, the trial shows that the high-carbon nickel Harveyed plate is undoubtedly the best armor plate ever subjected to ballistic test.

It may be assumed that the principle of supercarburizing steel to a considerable depth has passed beyond the experimental stage. The question of tempering or chilling the carburized armor plate needs, however, further experimental development, and the lack of uniformity in results, indicated in the Indian Head armor trials, may probably be ascribed to this want of experience. The assurance of success, however, is so great as to warrant the Department in making further experiment in this direction, with every reason for anticipating a completely satisfactory result."

BOOK NOTICES.

LECTURES ON EXPLOSIVES. Prepared especially as a manual and guide in the laboratory of the U. S. Artillery School, by Willoughby Walke, 1st Lieutenant, 5th Artillery. Artillery School Press: Fort Monroe, Va., 1891.

The subject is presented by Lieutenant Walke in the form of twenty-three lectures. He states in the preface that "the aim has been to present the subject systematically and logically, due consideration being given to the sequence in which the various classes of explosives are arranged, so that a certain degree of familiarity may be acquired in manipulating the less sensitive and dangerous mixtures before undertaking experiments with the high explosives." This intention has been well carried out, resulting in an excellent guide and reference book on explosives. The first four lectures are devoted to the chemistry, reactions, constitution and classification of explosive bodies, which are followed by six lectures on explosive mixtures, five of which are specially devoted to gunpowder, manufacture of various forms of it, tests, densimetry. After these the explosive compounds are dealt with in order. Separate lectures are devoted to gun-cotton; its manufacture at the U. S. Naval Torpedo Station; service tests of gun-cotton; nitroglycerine; gun-cotton powders and dynamites; smokeless powders; explosives of the Sprengel class; fulminates and similar compounds; manipulation, transportation and storage of high explosives; the use of high explosives for military purposes; the use of high explosives in shell; explosion by influence or sympathetic explosion. The *service tests* of the various explosives have received particular attention.
H. G. D.

THE ELASTIC STRENGTH OF GUNS. Meigs-Ingersoll. 1891. The Deutsch Lithographing and Printing Co.

The edition of the Elastic Strength of Guns published in 1885 by Lieutenants Meigs and Ingersoll having become exhausted, the latter officer has prepared this second edition for the use of naval cadets. Advantage has been taken of this to make a few changes and additions. There are additional explanatory figures, and all are placed on folding leaves for greater convenience. A large number of practical examples are inserted, the data coming from the new steel guns for the Navy, and a change in the notation assists the student in attacking the rather difficult problem of the computation of the shrinkages. A chapter on Longitudinal Strength is added, and one also giving the elementary principles governing the Construction of Wire-Wound Guns in view of what the author considers a probable development in that form of construction. The formulas of the book are Clavarino's, and for the purpose of comparison so much of Birnie's (Capt. Rogers Birnie, Jr., Ord. Dept., U. S. A.) formulas and work as necessary are given in the last chapter. The latter neglects the longitudinal strain, and computes the shrinkages from consideration of the gun in a state of rest, while the method of the text considers the longitudinal strains, and all computations proceed from a consideration of the strains in the gun when the maximum powder pressure is acting.
H. C. G.

A Course of Instruction in Ordnance and Gunnery, U. S. Military Academy. By Captain Henry Metcalfe, Ord. Dept., U. S. Army. Second edition, 1891. John Wiley & Sons.

This book is used as a text-book at the U. S. Military Academy in the course of instruction in Ordnance and Gunnery, and comprises a full treatise, so far as principles are concerned, on those comprehensive subjects. The chapters are conveniently subdivided by headings to paragraphs, which plan greatly assists the student and instructor. Numerous examples are inserted in appropriate places for solution. The plates are published in a separate volume, a feature which is sometimes considered an advantage. R. R. I.

BIBLIOGRAPHIC NOTES.

UNITED SERVICE GAZETTE.

DECEMBER 5 AND 12, 1891. The battle of Beaumont. The right of naval officers to resign. Naval notes: The Russian navy; French naval budget for 1892; Trials of the Eclair. The health of the navy, I. and II.

DECEMBER 19. Diagrams showing sea commerce and naval expenditure. The new French law on espionage. Armor-plate trials. Naval notes.

The new scheme of training seamen in gunnery is now in full development at Devonport, fully 550 men being now under training in the Cambridge. Under the new system all seamen are required to go through a course of 28 days' instruction in the gunnery ships, and an examination is to be held at the end of their course to determine whether further instruction is desirable. Those who display sufficient knowledge continue in the gunnery ships for another fifty days' training, and are then examined for the rating of seaman gunner, which carries with it the pay of 4*d.* a day extra. Efforts are being made as far as possible to supply newly-commissioned ships for foreign service with men who have been trained in gunnery.

Proposals of re-organization of the French naval engineer corps. Supplement: The truly perilous state of Great Britain should war occur between France and ourselves.

DECEMBER 26. Cadet-ship in the Royal Navy. Launch of the Montgomery. The United States new navy.

JANUARY 2, 1892. The ambulance in war. The United States navy. Russian field-mortar batteries.

JANUARY 9. Snow parapets.

The experiments on the resistance of parapets of snow to field-artillery projectiles were continued during 1891 in Russia. The results showed that plugged shell would pierce 18 feet of snow; that 22 feet of rammed snow and 25 feet of loose snow would give cover to field-artillery projectiles; that splinters of shell did not penetrate more than 20 feet; that it is extremely hard to lay accurately at snow works. The results indicate the best form of snow parapets as one of loose snow 25 feet thick. The range was 700 yards.

Spanish quick-firing guns.

JANUARY 16 AND 23. Naval *vs.* mercantile engineers. Training troops for battle. Gun trials at Portsmouth. French torpedo-depot ship Foudre. Sir Frederick Roberts on musketry.

JANUARY 30. The earnest appeal on behalf of the rank and file of the Royal Navy. Quick-firing guns in the Navy. H. G. D.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

DECEMBER, 1891. The question as to the military-political situation in the Mediterranean Sea. A light-cavalry regiment on active service. Mounted infantry patrols the necessary results of our present system of fighting. An artillery practice game. Note on some recent experiments with the submarine sentry.

JANUARY, 1892. Notes on organization and training. Notes on the attempted invasions of Ireland by the French in 1796–98. The reconnaissance work of the Home District Tactical and War Game Society. The naval schools of the chief Continental powers. The training of the seaman *personnel* in the German navy.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

DECEMBER, 1891. The Cantor lecture, 1890. The concentration of fire from forts. On the range-indicator dial. Notes of two lectures on field fortification, delivered at the School of Gunnery, Shoeburyness. The French manœuvres of 1891.

JANUARY, 1892. Notes of two lectures on field fortifications (continued). Naval attack of fortifications. Experiences at Okehampton in 1891. A retrospect of the equipment, service, etc., of the 1st and 2d Russian mountain batteries in the last war.

THE UNITED SERVICE.

DECEMBER, 1891. Education in the army. The United States steamer Michigan and the lake frontier during the War of the Rebellion. Marshal Augereau. The night express. Personal recollections of Sheridan's raid. History of the United States frigate Constitution (continued). An omitted Napoleonic chapter.

JANUARY, 1892. A word on the artillery question. History of the United States frigate Constitution (concluded). Colonel Burnaby's parents. The experiences of a staff officer in time of war. Should our harbor defenses be controlled by the navy?

FEBRUARY. The education of officers for the armies of to-day. Romance and rebellion. For the best interests of the service. Blockade-running. La haute école.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

NOVEMBER, 1891. Mounted infantry. Formulas for penetration of armor. Compilation of facts relating to high explosives. Post schools. The magazine staff and ammunition service in a sea-coast fort. Battle tactics. Artillery service in the War of the Rebellion. Some principles of organization of our coast artillery. Comment and criticism: The summary court; Range and position finding.

JANUARY, 1892. The terrain in military operations. A United States army. Rapid-fire guns. Discipline and tactics. Reminiscences of Tonquin. Comment and criticism: Magazine and ammu-

nition in a sea-coast fort; Mounted infantry; Battle tactics. Reprints and translations: Smokeless powder; Letters on infantry, XIII.; Service range-finding; Infantry attack; Artillery questions of 1890. Military notes: The Berthier rifle; Inspection report on British cavalry; The artillery of the future and new powder.

UNITED SERVICE INSTITUTION OF NEW SOUTH WALES.

LECTURE XII. Ambulance organization, equipment and transport for the mounted service.

LECTURE I. The organization and equipment of harbor defenses.

MILITÄR WOCHENBLATT.

OCTOBER 3, 1891. The French Soudan. Manœuvres at night-attacks on fortifications in Warsaw.

OCTOBER 7. The battle of Wörth. Experiments with carrier pigeons.

OCTOBER 10. The battle of Wörth (concluded). Review of the latest military inventions. Camp Crassnoe Selo. Armor tests in Japan.

OCTOBER 14. The field-piece of the future. Drills of sappers on the Veva.

OCTOBER 17. Max Jahn's history of military sciences. Military operations in East Africa. Steel turrets for Denmark. Walls of Toulon.

OCTOBER 21. Operations in East Africa, II. Bicyclists in the French army. (According to *La France Militaire* the number of bicyclists in the army is about 10,000.) Trials with smokeless powder in the United States.

OCTOBER 24. Operations in East Africa, III. Manœuvring divisions in the Russian army.

OCTOBER 28. Military society in Berlin. Operations in East Africa, IV. Trial of a 5.3-cm. rapid-fire Gruson gun. New Italian cavalry drill regulations governing the attack. Experiments in crossing rivers at Camp Kiev. French army manœuvres in 1892.

OCTOBER 31. Fighting tactics. Italian cavalry drill regulations governing the attack (concluded). Trials of Hotchkiss rapid-fire guns in France.

The Hotchkiss Company held a trial recently with their 47, 57, 76 and 100-mm. rapid-fire guns, during which several sorts of black and brown powder were compared with several kinds of smokeless powder (BN) in reference to muzzle velocity and gas pressure. For measuring the velocities taken at 40 meters from the muzzle, two chronographs, Le Boulenger and Breger, were used, which worked simultaneously through independent circuits. The pressures were measured by pressure gauges at the breech, and part in the bottoms of the cartridges. The results, which with equal pressure gave an average of about 100 meters in the muzzle velocity in favor of the smokeless powders, are shown as follows:

Gun.	Powder.	Weight of charge. Kg.	Weight of projectile. Kg.	Maximum pressure, atmospheric.	Muzzle velocity. Meters per second.
47 mm. heavy	C2	0.780	1.50	2320	610
	BN	0.425	1.50	2400	720
57 mm.	C brown	0.925	2.72	2420	600
	BN	0.465	2.72	2420	650
65 mm.	C brown	1.650	4.00	2420	630
	BN	1.025	4.00	2420	725
76 mm.	SP	3.200	6.40	2420	620
	BN	1.800	6.40	2320	735
10 cm.	SP	5.500	15.00	2370	565
	BN	3.100	15.00	2370	670

NOVEMBER 4. On military hygiene. Minor notices: English guns built in 1890; French recoil system for field-pieces.

NOVEMBER 7. Military hygiene (continued). Moltke's military works. Assignment of French naval battalions. New torpedo and gunnery school in Italy.

NOVEMBER 11. Military hygiene (concluded). The new Swiss military rifle. Fortifying Belforte.

NOVEMBER 14. The field-piece of the future. The 8-mm. Maxim gun in the Austrian army.

NOVEMBER 18. Observation ladder for field artillery. Competitive firing between artillery and infantry in Italy.

NOVEMBER 21. Heavy rapid-fire guns, II. Description of Canet rapid-fire guns. Drills and manœuvres at Camp Vladikawkas. French Mediterranean fleet.

The French fleet in the Mediterranean for 1892 is to consist of an active squadron in three divisions under one vice- and two rear-admirals, viz: 9 armor-clads, 4 cruisers, 2 torpedo cruisers, 3 avisos, 5 sea-going torpedo-boats, or 23 vessels in all. 2. A reserve squadron in two divisions under one vice- and one rear-admiral, viz: 6 armor-clads, 3 cruisers, 1 torpedo cruiser, 2 torpedo avisos, 12 vessels in all. This gives in all 35 war vessels, viz: 15 armored ships, 10 cruisers of different types, 5 torpedo cruisers, 5 sea-going torpedo-boats. In addition there are 15 war-ships lying in reserve at Toulon which could be ready for service within 14 days' notice.

NOVEMBER 25. Study on the war. On the autumn manœuvres on the east boundaries of France. Failures of English guns of large calibers.

NOVEMBER 28. Equipment of infantry.

DECEMBER 2 AND 5. Equipment of infantry. Heavy rapid-fire guns, III. Statistics on suicides in European armies. Military notes from Holland.

DECEMBER 16. French views on the influence of smokeless powder upon the tactics of field artillery. Gruson trials.

DECEMBER 19. The field-piece of the future.

DECEMBER 30. Military telegraph systems.

JANUARY 2 AND 6, 1892. Studies on the battle of Wörth. Tests of smokeless powder.

Important tests of Nobel powder have been concluded by the Krupp works. The object of the tests was to determine the deterioration, if any, in the powder caused by prolonged exposure to the atmosphere, as well as the effect of high temperature. To test the influence of the air, two kilograms each of several grades of the powder were stored for a year in such manner that the air had free access and could make its influence freely felt with every change in the weather. Accurate weighings were made every four weeks and recorded. At the expiration of a year the differences of these weighings varied from —1.6 grams to +1.6 grams, *i. e.* the powder lost or gained in dampness an amount equal to .08 per cent of its weight. The differences in the relative dampness of the different powders varied during the year from .14 to .24 per cent. Compared with ordinary powder, these results are highly satisfactory; in the latter the variations were at least five times as great. The coating of the grains with graphite was also of advantage, as the variations were least in powders so treated.

The injurious and, in fact, dangerous effect of prolonged exposure to heat is well known. Krupp shows conclusively by his tests that this danger does not exist in the smokeless powder. The powder was exposed first for a period of four days, and again for a period of fifteen days to a temperature of from 40° to 60° C., so that the metal cases containing it became so hot that they could not be handled with bare hands. On trial in an 8.7-cm. gun it was found that the initial velocity of 624 m. per second with powder at normal temperature (17°) rose only to 645 m. per second. The gas pressure increased only from 2320 to 2560 atmospheres. It is important to note that no exudation of nitro-glycerine took place during the heating.

The tests have proved the powder to be well fitted for use in war.

JANUARY 9 AND 13. The battle of Wörth (concluded). The Berthier rifle. Notes on the fighting tactics of General Ferron.

JANUARY 16 AND 20. The howitzer *vs.* ordinary field-piece. Test of nickel-steel plates in France. Growth of Russian railroads in 1891.

H. G. D.

DEUTSCHE HEERESZEITUNG.

OCTOBER 24 AND 28. Russian railroads from a military point of view (continued). New Italian rifle. Apyrite. Trial trips of two new Russian gunboats.

OCTOBER 31. Russian railroads (continued). The Maxim gun in the East African campaign. Rifles for the Russian army. Launch of the Brennus. Trials with the Snyder dynamite projectile.

NOVEMBER 4. Russian railroads from a military point of view (concluded). Comparison between European fleets. Optical firing in France.

NOVEMBER 7. Study of the Franco-Prussian war. Increase of the 6th French army corps. Result of the Zelewski expedition. Smokeless powder in the Swiss manœuvres.

NOVEMBER 11. The military forces of Corea. Transport of explosives in Germany.

NOVEMBER 14 AND 18. Strengthening Biserta. Budget of Austrian army and navy for 1892.

NOVEMBER 21 AND 25. Ship-building in France. Accidents with Nordenfeldt rapid-fire guns.

DECEMBER 9. Increasing the *personnel* of the German navy.

DECEMBER 23. New dry-dock in Kiel.

JANUARY 1, 1892. Krupp field-pieces in China.

JANUARY 6 AND 9. Infantry attack and infantry fire during the advance. The new rifle in Russia. Twenty-four hours of Moltke's strategy.

JANUARY 13 AND 16. Strengthening the French army. Trials of Krupp rapid-fire guns. The Graydon torpedo gun.

RIVISTA DI ARTIGLIERIA E GENIO.

OCTOBER, 1891. The development of field artillery. Upon the quartering of troops. Machiavelli and firearms.

NOVEMBER. The field-piece of the future. On the angle of elevation and its measurement.

DECEMBER. New and worn-out guns in field batteries. Stability of beams uniformly loaded. Extension of the ballistic formula.

RIVISTA MARITTIMA.

SEPTEMBER, 1891. Electric lighting on board Italian war-ships, by A. Ponchain (concluded). Naval schools in foreign countries and in Italy, by Dante Parenti (continued): description of French naval schools. Royal Naval Exhibition in London, by G. Cossavella. Vocabulary of powders and explosives, by F. Salvati (continued).

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JANUARY, 1892. Transmission of power by compressed air, by N. Soliani. The German merchant marine (continued). Naval schools in foreign countries and in Italy (continued). Study on the deviation and compensation of the compass, by P. Cattolica. Vocabulary of powders and explosives, by F. Salvati (continued).

H. G. D.

NORSK TIDSSKRIFT FOR SOVAESEN.

10TH ANNUAL SERIES, VOLUMES I. AND II. Prize essay. Yachts. Naval engagements in Chili. Target practice with shrapnel.

VOLUME III. Prize essay. On certain exhibits at the Naval Exhibition in Chelsea. Yachts. On the naval administration of England. Bursting of a Krupp 15-cm. gun. The new French armor-clad, Brennus. H. G. D.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

19TH ANNUAL SERIES, VOLUME IX. Notes on Spalato and Suva. Sailing directions for several regular routes. Report of a voyage from Cardiff to St. Rosalia, Guaymas, Pichilingue, and return. Voyage from Newport to Buenos Ayres, Barbadoes, New Orleans, and return to Bremen. The steamer routes from the Cape of Good Hope to Australia. The Kuro-Siwo or Japanese current. Contributions on the hydrography and topography of Onega Bay. Minor notices: Use of oil in quieting the sea; Sailing directions for Leith anchorage; Shehr and Macalleh on the south coast of Arabia; Navigation in Spencer Gulf, South Australia; Description of Lang-Kat river, Sumatra; Sailing directions for Makuny harbor, Pescadores Islands, China.

VOLUME X. Experiments with oil in quieting the sea. Remarks on the Tonga Islands. Remarks on voyages from Hamburg to Chili. Deep-sea explorations in the Ionian Sea and along the north coast of Africa. Deep-sea soundings in the Atlantic Ocean. Tides and currents in New York harbor and neighboring waters. Charts of magnetic elements for 1890. Quarterly weather review of the German Naval Observatory, spring of 1887. Minor notices: Use of oil in smoothing the sea in connection with a life-raft; Notices on the harbor of Santa Cruz, Teneriffe, Tarrafal Bay, Cape Verde Islands; Sailing directions for Bulari passage, New Caledonia; Quick voyages in the higher latitudes of the Indian Ocean.

VOLUME XI. Agreement of weather characteristics in northern Germany. Sailing directions to Port Jero and Port Kalloni, Mytilene. Voyages of the German ships Columbus and Eleanor Margaret from the Atlantic Ocean to Yokohama. Sailing directions for the mouth of the Deli, east coast of Sumatra. Deep-sea soundings in the Pacific Ocean. Quarterly weather review of the German Naval Observatory. Minor notices: On cooling drinking water in the tropics on board ship; Meteorological conditions in February and March, 1889, near the coast of Ecuador; Callao; Hygienic conditions of Rio Janeiro; Warning against use of the chart "Leadenhall Street" of Wilson, west coast of Australia. H. G. D.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XIX., NO. IX. On the launching of automobile torpedoes by means of powder, by Julius Heinz, captain, Imperial Navy.

Study on the rational oiling of ship's engines (extract from report of Chief Engineer G. Fontaine, French navy). Night signals, by Ensign A. P. Niblack, U. S. N. The French naval manœuvres, 1891. Ribbed fire-tubes for boilers. The new German line-of-battle ships. The Chilian war. Reconstruction of 35-meter French torpedo-boats. The Goubet submarine boat. Chronometer escapement. Bursting of an English gun. Automobile torpedoes in the United States. Launch of the Spanish torpedo-boat Rapido. Optical firing.

No. X. Consideration of the loxodromic curve from point of infinitesimals. On the launching of automobile torpedoes by means of powder, by J. Heinz (concluded). The artillery and torpedo school-ship of Italian navy. On a new invention to lessen vibrations of small lightly-built ships. The battle-ship of the future. English and French cruisers. The Sims-Edison torpedo. Brazilian school-ship. Launch of the English cruiser Endymion, of the German armor-clad Frithjof, of the Spanish cruiser Alfonso XIII., and the Galicia. Aluminium boat at the Frankfort exhibition. Testing the launching apparatus of the English ship Vulcan. Armor trials in the United States. A new range-finder for coast defenses.

No. XI. On the English fleet manœuvres, 1891. Determining position by Sumner's lines. On the tactics of torpedo-boats. On rapid-fire guns of large calibers. New harbor-defense booms. Tests of Snyder dynamite projectiles. Tests of nickel plates. The French line-of-battle ship Brennus. Floating supply stations for electric boats. Bursting of a Krupp 15-cm. gun. Canet rapid-fire guns of large calibers. H. G. D.

ELECTRICAL REVIEW.

VOLUME 19, NO. 1. A new theory of terrestrial magnetism. Another large telescope. Woodhouse and Rawson electric launches.

NO. 3. Queen's new photometer. Electric transmission of power.

NOS. 4 AND 5. The Montreal electric-light convention. Long-distance power transmission at Frankfort. A Swiss electric launch.

NO. 7. Recent progress in the use of electric motors. Sellers patent water-tube steam boiler. The Weston automatic engine.

NO. 9. Electric welding. Electricity in the Census.

NO. 16. Annual report of the naval inspector of electric lighting.

NO. 24. An electrical fog bell.

The port of Ravenna, in the Adriatic, has recently been provided with a fog-bell, the invention of the Abbé Ravaglia, and worked by electricity. It is situated at the end of the mole leading into the harbor, and the current is conveyed to it from a battery in the lighthouse, about a kilometer distant. The apparatus for striking the bell consists of a magneto-electric motor planted in the bell tower and connected to a mechanical puller. When the current from the battery passes through the armature of the motor, the motion of the armature is caused to turn a disk having pins projecting from its border. These pins catch on the end of a pivoted lever as the disk revolves, and by raising

one end of the lever depress the other, thereby pulling the bell chain and making the hammer strike the outer rim of the bell. A rapid series of strokes is the result, and the loud continuous note is heard for a long way. The battery employed is the constant form of Daniell, and a galvanometer is kept in the circuit to show that the current is of proper strength. A telephone circuit also enables the attendant at the lighthouse to hear the "drone" of the motor and thus know whether it is working at its proper speed. Such an apparatus is, under certain circumstances, cheaper, simpler, and more convenient than a steam siren or a bell actuated by the waves.—*London Times*.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

The handling of ingots and molds in Bessemer steel works. The Bendigo gold-field. The fuel supply of the United States. The tests and requirements of structural wrought iron and steel. Centrifugal ventilators. A new system of ore sampling.

THE JOURNAL OF THE FRANKLIN INSTITUTE.

JANUARY, 1892. The United States life-saving service. The subnormal in graphical dynamics. The port of Philadelphia. Experiments made to ascertain the specific volumes of saturated vapors of water, bisulphide of carbon, and ether; also the determination from the experimental data thus obtained of the mechanical equivalent of heat.

FEBRUARY. Bearing-metal alloys. Experiments, etc., for determination of the mechanical equivalent of heat (concluded). The specific heat of aluminium. Notes on electro-magnet machinery.

IRON AGE.

NO. 10, SEPTEMBER 3. Electrical appliances in a rolling mill (illustrated). Government tests of coil boilers (illustrated). Rapid naval construction. Foreign shipyards. The engines of the Maine.

NO. 11, SEPTEMBER 10. Steam steering gear. The armor question in 1891. Manufacture of nickelo-spiegel.

NO. 12, SEPTEMBER 17. Novel arrangement of triple-screw engines. Harrington's nickel-steel experiments. Gunpowder. Cruiser No. 9. Torpedo-boats for the navy.

NO. 13, SEPTEMBER 24. Distilling apparatus for the Maine. Petroleum in marine furnaces. The test of the Vesuvius. Vibration of torpedo-boats.

NO. 14, OCTOBER 1. A new German battle-ship.

The new German war-ship Kurfürst Friedrich Wilhelm, recently launched at Wilhelmshafen, is the first of four battle-ships now being built for the German navy. The other three are being constructed by contractors, two at Stettin and one at Kiel, but neither of them is yet launched. In fact, they are not nearly so far advanced as the one being built at the Government's works. The Kurfürst Friedrich Wilhelm is built of steel throughout, of German manufacture, and everything about the ship, excepting only the anchor-hoisting engine, is of German material. The stem is of three pieces of cast steel, of

which the middle one weighs 33,000 pounds. She is 380½ feet in length, draws 24½ feet, and is of 10,000 tons displacement. The ship has peculiar but graceful outlines, with sides having a deep tumble home amidships and a flaring bow. She is built on the longitudinal bracket system, has a double bottom and 120 water-tight compartments. The armor consists of a continuous belt of compounded steel armor 15¾ inches thick, on a teak backing. The width of the belt is nearly uniform throughout, and it is worked up against the ram, thus materially stiffening it. Her main armament consists of six 11-inch breech-loading rifles, in pairs, in three turrets; six 4.13-inch Krupp rapid-firing guns, built on an entirely new system, in broadside and protected by light armor; eight 3.43-inch guns, disposed chiefly for a raking fire ahead or astern; two rapid-firing guns in the military tops, and a number of revolving cannon and torpedo outfit. The boilers, engines and magazines are placed below a steel turtle-back protective deck, which descends below the water-line of the vessel. The other three vessels will be like this one, and each is designed for a 15 knots speed.

No. 15, October 8. The Weston automatic engine. The Belgian Mauser magazine rifle. The Victoria controllable torpedo (illustrated).

No. 16, October 15. Defending New York harbor. The new mortars, their design and manufacture (illustrated).

No. 17, October 22. Engine and helm control.

November 5. Torpedoes (illustrated).

November 12. New torpedo-boats. Armor-plate trials. The Miantonomoh.

November 19. Testing material for the Babcock and Wilcox boilers (illustrated). The Buffalo automatic injector. Adamson gun.

November 26. Engine castings in the new cruisers.

December 3. Experiments with high-tension currents. Making machine-guns. Launch of the New York.

December 10. The armor tests. Apparatus for hardening and tempering projectiles. Our achievements in naval construction.

December 17 and 24. Progress of naval construction. The safety valve. Electric reciprocating engine.

December 31. Steam boilers. Rapid-fire gun.

January 1, 1892. The whale-back. Transportation of ships. Steam boilers. Automobile torpedoes. Guns required for the navy. Smokeless powders.

January 14. The Beck steam steering gear. The Fiske electric position-finder. The U. S. cruiser Raleigh.

January 21 and 28. Torpedo-boat No. 2, U. S. N. Steam boilers. The Whitehead torpedo in Brooklyn.

February 4. Pneumatic disappearing carriage for 10-inch gun (illustrated).

H. G. D.

THE LONDON ENGINEER.

SEPTEMBER 11. Maxim on erosion in large guns. Engineers in the navy. Screw-propellers. Water-tube boilers in the United States Navy.

SEPTEMBER 18. Nordberg's automatic cut-off governor (illustrated). Steel in marine engine work. Petroleum oil engines.

SEPTEMBER 25. U. S. Cruiser No. 6. Surface condensers. Marine boilers. Marine engines in the U. S. Navy (illustrated). Practical expansion curves.

NOVEMBER 13. Armor-plate trials at Portsmouth.

NOVEMBER 20. The twin-screw steel steamer Ophir. Indian Head armor trials of plate manufactured in the United States. Accidents to English and French guns.

NOVEMBER 27. A new process for protecting iron and steel. Her Majesty's ship Nelson. Marine engines in the navy. Drying explosives in vacuum (illustrated).

DECEMBER 4. The Mills water-tube boilers.

DECEMBER 11. The resistance of steamships. High-speed gunboat. Canet quick-fire guns. Indian Head armor trials. Our monster guns.

DECEMBER 18. H. M. S. Thunderer. A new quick-firing gun. The Sims-Edison torpedo.

DECEMBER 25. Screw-propellers. Off-shore floating dock at Hamburg. Harfield's compensating steering gear (illustrated).

JANUARY 1, 1892. Engines for ships of war. War material.

JANUARY 8 AND 15. France and quick-fire guns. The navy of the United States, II. Steam engines for ships of war.

JANUARY 22. The navy of the United States, III. A French torpedo-boat.

THE MANUFACTURER.

SEPTEMBER 21, 1891. Smokeless powders.

During the course of some exhaustive and protracted experiments in Sweden the Apyrite smokeless powder has been produced, and it is reported that the new explosive has several distinct advantages over other known smokeless powders. The principal aims of the investigations were to obtain a smokeless powder based upon highly nitrated cellulose, with a low pressure of from 2200 to 2500 atmospheres, giving an initial velocity of from 630 to 650 meters, with no flame, but slight heating of the rifle, like ordinary black powder in appearance, and the products of combustion of which had an alkalescent reaction.

Apyrite is, to a large degree, unaffected by rubbing, rolling, or blows, and burns freely and without danger when ignited in even large quantities. This latter property was confirmed by an accidental ignition of some 80 kilograms of the powder in the drying room, when it was found that even some glasses which had been left in the room were quite unharmed. Its grains are prismatic in form, and bright and black in appearance, and cartridges can be charged by the ordinary appliances.

Even when heated to a high temperature in a stove Apyrite does not lose its original form, nor alter its consistency by massing together. It is almost smokeless—indeed, it excels other powders in this respect; it gives absolutely no flame, and the heating of the weapon used is exceedingly small. Experiments conducted to ascertain the comparative heating of rifle barrels have proved that 10 shots fired with nitro-glycerine powder, 15 with black powder, and 23 with Apyrite have the same effect of heating. A rifle with which 800 rounds had been fired, and which was left untouched for eight days, was then as easily cleaned as if cleaned immediately after firing. A canister containing Apyrite fired through at 50 meters range, neither exploded nor ignited for the first three shots, but at the fourth ignition took place, but the Apyrite burnt quickly without any report, and the canister was undamaged with the exception of the holes made by the bullets. In similar tests, with canisters filled with black powder and nitro-glycerine powder, an explosion occurred at the first shot, and the canisters were entirely destroyed.

In the present Swedish rifle, with a projectile weighing 14½ grains, it is proposed to use 3½ grains of Apyrite, and it is found that this gives the projectile a muzzle velocity of 640 meters, with a pressure of about 2260 atmospheres.

OCTOBER 20. A new projectile. Marine machinery. The Hall-Brown indicator.

ENGINEERING.

SEPTEMBER 4, 1891. Table showing results of firing trials with a Canet 32-centimeter 12.6-inch 66-ton gun of 40 calibers, made July, 1891, at Havre. Gun No. 11.

Number of Shot.	Weight of Shell.		Kinds of Powder.	Weight of Charge.		Muzzle Velocity.		Pressure.		Penetration in Wrought Iron.	
	Kilos.	Lbs.		Kilos.	Lbs.	Meters	Feet.	Kilos per sq. cm.	Lbs per sq. in.	Cm.	In.
1	333	734	P. B. S.	120	264	522.8	1715	782	11,120		
2	340	749	"	160	352	610.7	2004	1221	17,361		
3	345	760	"	160	352	610.2	2002	1347	19,155		
4	344	758	"	160	353	608.3	1996	1347	19,155		
5	450	992	"	240	529	689.9	2263	2517	35,796	111.0	43.69
6	451	994	"	240	529	690	2264	2515	35,708	111.1	43.73
7	450	992	"	240	529	690	2264	2384	33,908	111.1	43.78
8	451.5	995	"	240	529	690.1	2264	2553	36,309	111.1	43.73
9	451.5	995	"	240	529	692.2	2271	2740	38,971		
10	451	994	"	255	562	717.6	2354	2866	40,760	117.9	46.42
11	451	994	B. N.	135	297	670.2	2199	2089	29,710	106.8	42.05
12	450	992	"	140	308	700.7	2299	2421	34,430	112.7	44.36
13	450.5	993	"	144	317	727.4	2386	2553	36,304	120.3	47.36

This second gun, like the first, is intended for service in a barbette turret with a Canet central loading arrangement, so that the gun can be loaded in any position. When the gun was brought from the factory to the testing ground it was mounted on its own carriage, which was also made by the Forges et Chantiers. The test comprised the firing of thirteen rounds, in one of which the charge was raised so as to increase the pressure in the gun to 39,800 pounds per square inch; both gun and mounting resisted this extreme pressure without any injury.

The most interesting feature of these trials was the extended employment of the French smokeless powder of the B. N. mark. With a charge of 144 kilograms of this powder an initial velocity of 724 meters was obtained. This was a great deal better than was given by the first gun tried some months ago.

On that occasion the maximum charge of this explosive fired was 135 kilograms, and the velocity recorded was 701.7 meters. The pressure in the gun was of course increased with the greater charge, but not sufficiently to strain the gun dangerously.

With the maximum powder charge the projectile, weighing 450 kilograms, left the gun with an energy of 1250 metric tons, corresponding to a penetrating power at the muzzle of 120.3 centimeters through wrought iron; the penetrating power of the English 110-ton gun is 120.7 centimeters. The Krupp gun of 120 tons has a corresponding penetrating energy of 126 centimeters. It would appear, therefore, from this comparison that the Canet 66-ton gun has a penetrating power equal to these enormous calibers, and the interesting fact is demonstrated by the recent trials, that a gun one-half the weight of the unwieldy and enormously costly Krupp gun can be made of practically the same efficiency at less than half the expense and with a longer term of useful life. Moreover, comparing the trials of the second with those of the first Canet 66-ton gun, it is reasonable to suppose that still better duties can be obtained, and doubtless will be obtained, with other guns of the same caliber now being made by M. Canet at Havre. Of course considerable progress is also being made with the smokeless powders, and better results than have yet been obtained may be confidently looked for. The explosive used during the recent trial had not been previously employed with such large calibers, except for the first 66-ton gun in January last, and since that date some improved methods of utilizing it had been devised.

SEPTEMBER 11. Marine engineering at Cowes (illustrated). Vibration of torpedo-boats. Turbines at Assling-Sava, Carniola (illustrated).

SEPTEMBER 18. The Morris circulating filter. The Nova Scotian steamer Boston (illustrated). Welded boilers. The Serpollet boiler. Sea-going torpedo-boat for the Brazilian navy. Marine engineering during the past decade (conclusion). The Middelgrund fortification outside Copenhagen.

SEPTEMBER 25. The Presidente Pinto (illustrated). The Serpollet boiler. Coal-burning of Atlantic liners. Compound engines.

OCTOBER 2. Steam boiler experiments, No. VII. The Swiss magazine rifle (illustrated). The spacing and construction of watertight bulkheads.

OCTOBER 9. The Maxim automatic machine-gun (illustrated). The French navy, No. XVI.: The Richelieu. The forging press. Torpedo-boat stations and coast defense.

OCTOBER 16. The Maxim automatic machine-gun (concluded). The Thornycroft boiler in France. Weldron's range-finder.

OCTOBER 23. Armor-plate bending rolls. The British cruisers Terpsichore, Thetis, and Tribune (illustrated). The velocity of projectiles.

OCTOBER 30. Disappearing turrets for Nordenfeldt quick-firing guns (illustrated). The French navy, No. XVII.: The Sfax. A torpedo-boat boom.

NOVEMBER 6. Compound armor-plates. The Adamson gun (illustrated).

The leading feature of the weapon is the substitution for trunnions or grooves, of a spherical enlargement, which works in a correspondingly shaped socket on the carriage or mounting. By means of this ball-joint the gun can be rapidly trained, both vertically and horizontally. This feature is claimed as an advantage over the usual systems. The gun was made at the Bofors works in Sweden, and recently tested by two Swedish government artillerists. The following are the particulars: Caliber, 3.36 inches; total length, 98.43 inches; weight, 1200 pounds. Rifling: Number of grooves, 24; depth, .295 inch; width of lands, .138; twist—muzzle, 33 calibers. Weight of shell, 14.77 pounds; weight of charge (black powder), 5.51 pounds; muzzle velocity (black powder), 1920 feet; muzzle velocity (smokeless powder), 1970 feet.

With a muzzle velocity of 1984 feet per second the energy in the shot was 406 foot-tons, or 726 foot-tons per ton of gun, which was exceedingly good for a gun of only 24 calibers length.

Three series of five rounds each were fired to test the rapidity, and they occupied respectively 30 seconds, 25 seconds, and 20 seconds. At 25 degrees elevation the range was 26,250 feet, and the pressure varied between 19.8 and 21 tons per square inch. Eighty-five rounds have been fired in all with good results. The breech mechanism was of the Bofors pattern.

NOVEMBER 13. Japanese coast-guard ships. Armor-plate trials. A chronological history of electricity (continued).

NOVEMBER 20. The new Orient liner Ophir. The Franklin life-buoy. Lancashire boilers. Trials of H. M. cruiser Blake.

NOVEMBER 27. The new Orient liner Ophir. Rees magazine rifle (illustrated). The Indian Head armor trials. Fiske's electrical position-finder.

DECEMBER 4. The Atlantic liner, past, present and future. Screw propulsion with non-reversible engines. Naval *vs.* mercantile engineers. Riveted joints (illustrated).

DECEMBER 11. The United States Navy exhibit at Chicago (illustrated). Efficiency of centrifugal pumps.

DECEMBER 18. Quick-firing guns. The form of ships' hulls. Additions to the navy in 1891. Marshall and Wigram's balanced slide-valve.

DECEMBER 25. Canet *vs.* Krupp guns. French sea-going torpedo-boats. The Benardos system of electric welding. Nickel-steel armor trials. Water-gauge fittings for steam boilers.

JANUARY 1, 1892. Ship-building in the United Kingdom in 1891. The first-class cruiser Edgar. Canet *vs.* Krupp guns (continued).

JANUARY 8. The Marque screw propeller. High-speed engine and dynamo. Trial of a steam turbine dynamo. Chronological history of electricity (continued).

JANUARY 15. Canet *vs.* Krupp guns. The first class-cruisers Edgar and Hawke (illustrated).

DIMENSIONS, ETC., OF SEVERAL FAST CRUISERS.

	H. M. S. Edgar.	H. M. S. Blake.	H. M. S. Australia.
Length	360 ft.	375 ft.	300 ft.
Breadth	60 ft.	65 ft.	56 ft.
Draught (mean)	23 ft. 9 in.	25 ft. 9 in.	22 ft. 6 in.
Displacement	7350	9000	5600
Indicated horse-power (mean)	12,463	14,535	8500
Speed (knots)	20.97	19.3	18.5
Coal on designed draught (tons)	850	1500	900
Endurance at 10 knots	10,000	15,000	8000
Protective deck slopes	5 in. and 2 in.	6 in. and 4½ in.	Belt
Flats	2½ in.	3 in.	..
Armament	2 9.2-in. B. L.; 10 6-in. R. F.; 16 6-pdrs.; 3 3-pdrs.; 8 machine.	2 9.2-in. B. L.; 10 6-in. R. F.; 16 3-pdrs.	29.2-in. B. L.; 10 6-in.; 16 R. F.; 7 machine.

	U. S. New York.	Commerce Destroyer (U. S.)	French Cécille.
Length	380 ft.	412 ft.	378 ft.
Breadth	64 ft. 10 in.	58 ft.	49 ft. 3 in.
Draught (mean)	23 ft. 3½ in.	24 ft.	19 ft. 9 in.
Displacement	8150	7475	5766
Indicated horse-power (mean)	16,500	21,000	9600
Speed (knots)	20	22	19
Coal on designed draught (tons)	..	750	..
Endurance at 10 knots	..	9800	..
Protective deck slopes	6 in. and 3 in.	4 in.	..
Flats	3 in.	2½ in.	..
Armament	6 8-in. B. L.; 12 4-in. R. F.; 8 6-pdrs.; 4 1-pdrs.; 4 Gatlings.	4 6-in B. L.; 12 4-in R. F.; 16 6-pdrs.; 8 1-pdrs.; 4 Gatlings.	6 6.3-in. 5-ton B. L. R.; 10 5.49-in. 3-ton B.L.R.; 3 Q.F.; 10 machine.

Tests of single cylinder, compound and triple-expansion cylinders of same type. Chronological history of electricity (continued).

JANUARY 22. Canet *vs.* Krupp guns (continued). Torpedo-boat for Victoria (illustrated). The want of torpedo-boats. A new French torpedo-boat. H. G. D.

THE STEAMSHIP.

NOVEMBER, 1891. Screw propellers.

Commenting on the results of the discussions in the columns of the leading engineering journals, extending over a considerable period of time, as to the best design of propeller to suit any given vessel, Mr. Winterburn states that the results are practically *nil.* After a wordy warfare, in which some of the best-known names connected with the English technical colleges and many able designers of ships have figured, it appears that the question is in precisely the same condition as before, and the most suitable propeller for any given design of hull still remains a result of trial and error. Startling arrays

of figures have been published, showing how the stern lines affect the closing in of the wave made by the vessel; the angle of incidence where each particle of water strikes its corresponding portion of the blade, the angle at which it is projected off, and the resultant deduced therefrom, by which the most suitable blade can be designed and its velocity ascertained; full, straight, and hollow lines of hull have each their adherents; in fact, every possible style of vessel and shape of propeller have their partisans, who have fought for their particular hobbies; yet nothing has been evolved which will convince an unbiased mind that any given propeller is the best possible for the vessel for which it is intended.

The dynamics involved in the lines and speed of ships. Steam-engine efficiency. Screw propulsion with non-reversible engines.

A description, with illustrations, of Beaumont's method of screw propulsion, with feathering bladed screw, by means of which the engines always move in the same direction.

By means of this invention, as Mr. Beaumont points out in his paper, it is possible to achieve several ends which are of great importance, some of which may be enumerated as follows: (1) the propulsion of ships by means of screws which always rotate in the same direction and may be actuated by non-reversible engines and screw shafts; (2) the simplification of marine engines, by dispensing with all the parts used for making the engines reversible; (3) the complete and quick reversal of the direction of propulsion without any of the heavy stress tending to rupture of screw shaft and couplings; (4) the easy adjustment of the pitch while the engines are running.

DECEMBER. A comparison between double and triple-expansion engines. Tests of wrought-iron lap-welded main steam-pipes for marine boilers.

Detailed results of a test made in Glasgow under the supervision of the officers of the Board of Trade and Lloyds.

JANUARY, 1892. Improved boiler flue flange drilling machine. The relation of engineering and naval instruction. J. K. B.

THE RAILROAD AND ENGINEERING JOURNAL.

JANUARY, 1892. Notes on combustion. Tests of a compound locomotive. Progress in the United States navy. The trials of American made armor plate. Foreign naval notes.

FEBRUARY. A thermo-electric method of studying cylinder condensation. Army ordnance notes. Recent armor trials.

J. K. B.

INSTITUTION OF MECHANICAL ENGINEERS.

A review of marine engineering during the past decade.

In this paper Mr. Blechyden starts with the introduction of the triple expansion engine, and gives a general resumé of the changes consequent upon a higher boiler pressure and increased expansion; taking them up under the following heads: 1. Modifications in the engine; 2. The valve gear and valves; 3. The pumps; 4. The boilers, the change in material used and the advance in application of tools to boiler-making, corrugated, ribbed and spiral flues; 5. Forced draught, the methods in use and their economy; 6. Steam pipes, feed-heating and the auxiliary supply of fresh water; 7. Screw propellers and the weight of machinery per H.P. J. K. B.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIP-BUILDERS.

VOLUME VII., 1891. Increased boiler pressure and increased piston speed for marine engines.

The object of the author in this paper was to raise a few questions as to the advisability of increasing the working pressure and the piston speed, and to consider what type of engine and boiler would best suit these new conditions.

Screw propeller.

A paper read by Mr. Blechyden, on the influence of the relative dimensions and proportions of the screw propeller on the vessel's performance, with a comparison of the trial data of certain vessels, and of the relation of the dimensions of the screws to the sizes of the vessels they were used to propel. Also a method of calculating the power which can be developed upon a screw of given dimensions, based on the model experiments, and by a series of examples is shown the relation of the calculated powers to those obtained on trial.

The strength of short flat-ended cylindrical boilers. Water-gauge fittings for steam boilers. Electrical engineering. Results of experiments on the strength of boilers. The unsinkability of cargo-carrying vessels. J. K. B.

TRANSACTIONS AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

VOLUME XII., 1891. Chimney draught, facts and theories (Thurston). Special experiments with lubricants (Denton). Authorities on the steam jacket: facts and current opinions (Thurston). Tests of a triple-expansion engine (Henthorn). A belt dynamometer (Alden). Steel castings (Gault). Notes regarding calorimeters (Carpenter). The application of Hirn's analysis to the multiple expansion engine (Peabody). Mechanical stokers (Roxey). Manganese steel (Howe). The effect of a steam jacket upon cylinder condensation (Bird). A belt dynamometer (Watt). The report of committee on a standard method for conducting the duty trials of pumping engines. Steam-engine efficiencies (Thurston).

J. K. B.

TRANSACTIONS AMERICAN SOCIETY OF MINING ENGINEERS.

VOLUME XIX., 1891. Explosions from unknown causes. The protection of iron and steel ships against foundering, from injury to their shells. The development of the marine engine and the progress made in marine engineering during the past fifteen years. On welding by electricity. The inspection of materials of construction in the United States. Fuel gas and some of its applications. Aluminium steel. Spirally welded steel tubes. Notes on the Bessemer process. International standards for the analysis of iron and steel. The iron ores of the United States. Cast-iron tools for cutting metal. The progress of German practice in the metallurgy of iron and steel.

J. K. B.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

NOVEMBER, 1891. Fan-blowers. Theory of the centrifugal pump. Some new alloys. Electric lighting of ships. Radial valve gears. Speed curves of ships building for the U. S. Navy. Rational lubrication of marine engines. Spontaneous ignition of coal. Speed trials. Notes on superheating steam, the Harvey process of hardening steel, and the efficiency of steam separators. J. K. B.

CASSIER'S MAGAZINE.

DECEMBER, 1891. The technical schools of America. The influence of steam jackets. Water rams in steam pipes. Electric power distribution. Mechanical refrigeration. J. K. B.

THE STEVENS INDICATOR.

OCTOBER, 1891. Lecture notes on steam hammers and hydraulic forging and riveting. The performance of a steam reaction wheel. The relative merits of various steam tables. Oils used in lubrication. J. K. B.

INSTITUTION OF MECHANICAL ENGINEERS.

APRIL, 1891. Research committee on marine engine trials: Report upon trials of the S. S. Iona, by Prof. Kennedy. J. K. B.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

SEPTEMBER, 1891. Notes on the present position of the question of transmission of power.

A paper containing a record of what has been done in the transmission of power by steam, compressed air, hydraulic power, ropes, and by electrical transmission. J. K. B.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

VOLUME XXV., OCTOBER, 1891. Screw steamship and tow-barge efficiency. On the Straits of Juan de Fuca, Puget Sound, and government improvements on the Pacific Coast. Some recent experiments with dynamite on an ocean bar. J. K. B.

LE YACHT.

JULY 11, 1891. French naval manœuvres. Mobilization of 1891.

The article gives, with a complete list of the vessels participating in the third series of the manœuvres, the general dispositions taken to serve as a guide to the belligerents. The theme is a simple one. A squadron, A, sails north from Gibraltar between the Balearic Isles and the Spanish coast. Another squadron, B, cruising about to protect the coasts of France and Corsica, is informed by telegraph that the squadron A has just rounded Cape Gate, and thereupon advances to meet and intercept the latter between Majorca and Barcelona. The advantage of speed is on the side of A, while B has that of number and fighting power.

The armored battleships may not develop more than 8.5-tenths of the maximum number of revolutions exhibited in their trials; light vessels may develop 9-tenths of their power, with forced draft. Torpedo-boats are at liberty to use all their speed.

The fighting power of each vessel, with the exception of torpedo-boats, is determined by a numeric coefficient. In the case of the vessels of squadron A succeeding in reaching the coasts of France or Corsica, they must remain near their objective points of attack for six hours at least, three of which of daytime, and be superior in force to the land and floating defenses confronting them, before said points are considered subdued.

In order to accomplish this, a numeric coefficient of warlike power is given to the land defenses of the following cities: Toulon, Marseilles, Villefranche, Nice, Ajaccio, Port Vendres, Cette, Antibes, Bastia; the other seaports being supposed defenseless. The roads of Hyères remain neutral. Hostilities shall cease at the latest at eight o'clock in the morning of July 11. After that hour all the vessels, even those attached to the defenses of the sectors, will rendezvous in the roads of Hyères.

Rules: Vessels may, when so authorized or ordered by their respective commanders-in-chief, screen their running lights, so arranged that they may be exhibited instantaneously. When two hostile vessels or forces shall approach one another at a distance equal or inferior to 2000 meters they will invariably be considered as in action; the doors of the water-tight compartments must be closed, and at night the running lights as well as station lights must show on all the vessels with the exception of torpedo-boats.

The combat shall be supposed ended (1) as soon as the vessels have steamed past each other in opposite directions; (2) when both adversaries being situated end on, have remained for at least twenty minutes at a distance of 2000 meters from one another.

Will be considered as having taken part in an action the following vessels only: (1) Vessels acting singly that have kept within 2000 meters of the enemy for twenty minutes, or have steamed past on opposite tacks at a distance of less than 1000 meters; (2) Vessels belonging to a group formed in tactical order with intervals and distances below 1000 meters, when any one of the vessels forming part of the group will have found itself in the position described in the first part of the paragraph.

In the case of an engagement, the coefficient of the fighting power of all vessels considered as having been in action shall be added together on each side, after deducting half the coefficient of those that have been torpedoed during the combat. The results shall be determined by the following rules: In case of the sums of the coefficients being equal, the combat will be considered undecided; in fact, a drawn battle. The hostile forces are then to separate 50 miles in daytime and 30 at night, both steaming back half the distance they came from, the use of scouts not being allowed. They will then recover their freedom of action.

In case of the sums being unequal: If the two sums of coefficients are in a ratio of 3 to 2, the weakest side shall be considered as destroyed and will repair to the islands of Hyères. If the ratio of the two sums be equal or inferior to 3 to 2, the weakest side shall lose one of its strongest fighting units, which then steams back to Hyères. The other vessels separate as in the case of a drawn battle.

Torpedo-boats may simulate attacks, taking care in case of an action in columns on contrary tacks not to deviate more than 200 meters from the line of file of their own squadron. Torpedo-boats having exhausted their supply of torpedoes may not simulate other attacks before receiving fresh supplies from the battle-ships; the renewal of supplies will be merely feigned. Fighting ships, with the exception of torpedo-destroyers, may be torpedoed by torpedo-cruisers, dispatch torpedo-boats, and torpedo-boats. To accomplish this, two light vessels must be in a position to fire their torpedoes at the same

vessel within a distance of 500 m. during an interval of thirty minutes in daytime or two hours at night, provided they remain no longer than ninety minutes under the fire of the quick-firing guns of the assailed vessel. A ship torpedoed four times from the beginning of hostilities will be considered *hors de combat* and will return to Hyères. After each engagement the commander-in-chief, and in his absence the senior captain, embarked as one of umpires, will decide and signal the results of the affair, applying the foregoing rules.

The auxiliary petroleum motors of Messrs. Forest and Gallice. Description of recent torpedo-destroyers (contre-torpilleurs). First-class cruiser Jean Bart.

AUGUST 8. The armor-clad division of the North. Squadrons' scouts. In a conning tower; or how I took H. M. S. Majestic into action, translated from the English, is an article on the model of the "Battle of Port Saïd" and other imaginary combats.

DECEMBER 19. Comparison between the Canet and the Krupp guns.

The author of this article, taking to task the Dresden "Internationale Revue," pointing out a great many inaccuracies, and reviewing the fact in all its aspects, comes to the conclusion that the Canet gun is superior to any gun now in existence.

The American cutter yacht Gloriana. J. L.

JANUARY 2, 1892. The war navies of 1891.

An article in which E. Weyl reviews the principal naval events of the past year.

JANUARY 9. The war navies of 1891 (continued). Technical naval association: a note touching the stability of torpedo-boats in the swell of the sea, by M. Ferrand. The Shipping World Year-Book for 1892.

JANUARY 16. The necessity for war fleets (E. Weyl).

JANUARY 23. The armored battle-ships of the Triple Alliance: the German armor-clads.

REVISTA TECNOLÓGICO INDUSTRIAL.

DECEMBER, 1891. An appeal from the "Material para ferrocoriles" Company of Barcelona, to be awarded the contract for furnishing the 70 postal cars advertised for by the Spanish government. A history of flour-mills and bakeries from the earliest ages to this day (ended).

BOLETIN DEL CENTRO NAVAL, BUENOS AIRES.

SEPTEMBER, 1891. A public reception tendered to the President of the Republic by the "Centro Naval" Club. The President on board the new battle-ship, 25 de Mayo. Review of the whole fleet in the roads, on Sept. 3, 1891.

REVUE DU CERCLE MILITAIRE.

DECEMBER 20, 1891. Notes on the German army, by an English officer (ended). Utilization of long ranges (rifle model, 1886). Notes on the Chinese army (continued).

DECEMBER 27. How does the question of the small-caliber gun stand? Notes on the Chinese army (ended). Utilization of long ranges, etc. (ended).

JANUARY 3, 1892. Electric search-lights in the army; experiments made in different countries. Projected strategic railway on the Rhine.

JANUARY 17. Field-howitzers in the Russian army (ended). The Franco-Italian frontier (with a separate map), (ended).

JANUARY 24. The German cavalry as viewed from the standpoint of an Englishman. J. L.

THE WESTERN SOLDIER.

BULLETIN OF THE AMERICAN IRON AND STEEL ASSOCIATION.

TEKNISK TIDSKRIFT.

TRANSACTIONS AND PROCEEDINGS OF THE GEOGRAPHICAL SOCIETY OF THE PACIFIC

VOLUME II., NO. 1. Humboldt Bay, by Prof. Geo. Davidson. Geographical and ethnological notes on Alaska, by Ivan Vetroff. Corea, the hermit kingdom, by J. T. Scott.

OUTING, a Monthly Magazine.

THE COLLIERY ENGINEER.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES Volume III., Part 1.

MÉMOIRES ET COMPTE RENDU DES TRAVAUX DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

REVISTA TECNOLOGICO INDUSTRIAL.

BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY, Dec. 31, 1891.

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY, Volume XXIX., No. 136.

BOOKS AND PERIODICALS RECEIVED.

GOLDTHWAITE'S GEOGRAPHICAL MAGAZINE.

MINERALS, a Monthly Magazine.

BEITRÄGE ZUR GEOGRAPHIE DES FESTEN WASSERS. Published by the Verein für Erdkunde, Leipzig.

REPORT ON UNIFORM SYSTEM FOR SPELLING FOREIGN GEOGRAPHICAL NAMES.

POSTAL SAVINGS BANKS; AN ARGUMENT IN THEIR FAVOR BY THE POSTMASTER-GENERAL. Annual report of the Postmaster-General of the United States, for the fiscal year ending June 30, 1891.

TABLES CONDENSÉES POUR LE CALCUL RAPIDE DU POINT OBSERVÉ, par E. Serres, Lieutenant de Vaisseau.

ANNUAL REPORT OF THE LIEUTENANT-COMMANDER FIRST BATTALION NAVAL RESERVE ARTILLERY OF THE STATE OF NEW YORK.

ANNUAL REPORT OF THE INSPECTOR-GENERAL FOR THE YEAR 1891.

REPORT OF THE BOARD OF ENGINEER OFFICERS OF THE U. S. NAVY ON WARD'S WATER TUBE MARINE BOILER.

CENSUS BULLETINS.

ALMANACH DER KRIEGS FLOTTEN, 1892.

TRANSLATORS AND REVIEWERS.

Lieutenant R. R. INGERSOLL, Lieutenant H. C. GEARING,
Professor JULES LEROUX, P. Asst. Engineer J. K. BARTON,
Ensign H. G. DRESEL.

ANNUAL REPORT OF THE SEC. AND TREAS. OF THE U. S. NAVAL INSTITUTE.

To the Officers and Members of the Institute.

Gentlemen :—I have the honor to submit the following report for the year ending December 31, 1891 :

ITEMIZED CASH STATEMENT.

Receipts during Year 1891.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Advertisements..........	$287 50	$100 00	$150 00	$69 90	$607 40
Dues	1225 70	490 00	252 56	377 37	2345 63
Sales....................	1238 94	40 65	181 04	341 09	1801 72
Subscriptions............	228 90	351 65	193 25	224 85	998 65
Life-membership fees.....	120 00	30 00	....	60 00	210 00
Binding, extra...........	18 65	12 18	3 00	8 35	42 18
Interest on deposits......	70 97	9 00	80 88	9 00	169 85
To stamps and premium, money orders..........	59	3 44	03	25	4 31
Registry charges and alterations, No. 56..........	9 58	....	....	....	9 58
Overcharges, No. 58......	....	....	40 79	....	40 79
Printing half tones........	....	....	175 37	45 44	220 81
Credit Hudson's list.....	....	....	1 00	...	1 00
Freight and hauling......	....	....	....	1 02	1 02
Totals...............	$3200 83	$1036 92	$1077 92	$1137 27	$6452 94

Expenditures during Year 1891.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Printing and binding publications................	$1564 52	$520 93	$800 54	$1450 43	$4336 42
Extra reprinting..........	...	....	164 25	....	164 25
Extra binding............	1 30	18 65	9 30	....	29 25
Freight and expressage...	14 59	18 08	12 28	12 65	57 60
Postage..................	55 64	58 32	25 05	32 05	171 06
Telegrams................	1 36	29	25	1 17	3 07
Stationery...............	11 23	38 70	....	7 25	57 18
Office expenses...........	1 25	1 97	1 75	83	5 80
Purchase of bonds........	242 25	....	....	....	242 25

EXPENDITURES DURING YEAR 1891.—*Continued.*

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Purchase of back numbers.	$7 12	....	....	$5 25	$12 37
Purchase of seal press....	5 00	....	....	....	5 00
Subscription Army and Navy Register..........	3 00	....	....	....	3 00
Secretary................	90 00	$90 00	$90 00	90 00	360 00
Secretary's salary Dec. '90	30 00	....	....	....	30 00
Clerk....................	120 00	120 00	120 00	120 00	480 00
Annual prize.............	100 00	....	....	....	100 00
Gold medal and engraving	18 00	....	....	....	18 00
Expenses Newport Branch	50	....	....	....	50
Expenses Washington Branch................	2 45	....	....	1 55	4 00
Half profits, No. 34.......	7 59	....	....	....	7 59
Refunding sight draft.....	....	....	3 00	....	3 00
Insurance on stock.......	....	...	....	12 50	12 50
Electrotypes No. 60......	....	....	....	18 00	18 00
Totals..............	$2275 80	$866 94	$1226 42	$1751 68	$6120 84

SUMMARY.

Balance of cash unexpended for the year 1890	$1717.92
Total receipts for 1891	6452.94
Total available cash, 1891	$8170.86
Total expenditures for 1891	6120.84
Cash unexpended, January 1, 1892	$2050.02
Cash held to credit of Reserve Fund	127.19
True balance of cash on hand, January 1, 1892	$1922.83
Bills receivable for sales of No. 60	80.00
" " " dues, 1891	522.00
" " " back dues	376.00
" " " binding	26.00
" " " subscriptions	104.00
Institute property, including back numbers on hand	3515.00
Total assets	$6545.83

It may be noted that during the year 1891 one extra number of the Proceedings, No. 56, was published, and the printing of six numbers, 55 to 60 inclusive, was paid for, leaving no outstanding bills.

RESERVE FUND.

List of bonds deposited for safe-keeping in the Farmers National Bank of Annapolis, Md.:

United States 4 per cent registered bonds	$900.00
District of Columbia 3.65 per cent registered bonds	2000.00
" " " " coupon "	350.00
	$3250.00
Cash in bank uninvested	127.19
Total Reserve Fund	$3377.19
Annual interest on bonds	121.77
Number of new life members	4

During the year four District of Columbia bonds, 3.65 per cent, face value $200, were purchased for $242.25.

Membership.

The membership of the Institute to date, January 1, 1892, is as follows: Honorary members, 6; life members, 104; regular members, 560; associate members, 180; total number of members, 850.

During the year 1891 the Institute lost 32 members by resignation and 11 by death. 63 new members' names were added to the rolls; viz. 39 regular, 20 associate, and 4 life members; 3 regular members became life members.

Members Deceased since January 20, 1891.

Life Members.

Floyd, Richard, July, 1891.
Paul, A. G., Lieutenant, U. S. N., May 13, 1891
Watrous, C., August, 1891.

Regular Members.

Carter, S. P., Rear-Admiral, U. S. N., May, 1891.
McGregor, C., Commander, U. S. N., July, 1891.
McLane, A., December 16, 1891.
Norris, G. A., Lieutenant-Commander, U. S. N., July, 1891.
Rodgers, C. R. P., Rear-Admiral, U. S. N., January 8, 1891.
Yates, A. R., Captain, U. S. N., November 18, 1891.

Associate Members.

Campbell, J. B., Captain 4th Artillery, U. S. A., August 28, 1891.
Falsen, C. M., Lieutenant, N. Navy, 1891.

Circulation of the Proceedings during the Year 1891.

	First Quarter. No. 56.	First Quarter. No. 57.	Second Quarter. No. 58.	Third Quarter. No. 59.	Fourth Quarter. No. 60.	Tota .
Members	872	872	869	866	863	4342
Subscriptions	251	251	251	252	154	1159
Exchanges	102	102	100	100	100	504
Sales	1141	8	4	1	602	1756
Sale of back numbers	66		13	115	16	210
	2432	1233	1237	1334	1735	7971

Corresponding Societies and Exchanges.

United States.

American Academy of Arts and Sciences, Boston, Mass.
American Chemical Journal, Baltimore, Md.
American Geographical Society, New York, N. Y.
American Institute of Mining Engineers, New York, N. Y.
American Iron and Steel Association, Philadelphia, Penna.
American Metrological Society, Columbia School of Mines, New York, N. Y.
American Philosophical Society, Philadelphia, Penna.
American Society of Civil Engineers, New York, N. Y.
American Society of Mechanical Engineers, New York, N. Y.
American Society of Naval Engineers, Navy Department, Washington, D. C.
California Academy of Sciences, San Francisco, Cal.
Cassier's Magazine, New York, N. Y.
Colliery Engineer, Scranton, Penna.
Connecticut Academy of Arts and Sciences, New Haven, Conn.
Electrical Review, New York, N. Y.
Elliott Society, Charleston, S. C.
Franklin Institute, Philadelphia, Penna.
Geographical Society of the Pacific, San Francisco, Cal.
Journal of the Association of Engineering Societies, St. Louis, Mo.
Journal, The Railroad and Engineering, New York, N. Y.
Journal of the U. S. Cavalry Association.
Lend-a-Hand, Boston, Mass.
Mechanics, Philadelphia, Penna.
Military Service Institute of the United States, Governor's Island, N. Y.
School of Mines Quarterly, New York, N. Y.
Smithsonian Institute, Washington, D. C.
Technical Society of the Pacific Coast, San Francisco, Cal.
The Engineer, New York, N. Y.
The Iron Age, New York, N. Y.
The Railroad Gazette, New York, N. Y.

The Stevens Indicator, Hoboken, N. J.
The United Service, Philadelphia, Penna.
Wagner Free Institute of Sciences.

FOREIGN.

Annalen der Hydrographie, Berlin, W., Prussia.
Asociacion de Ingenieros Industriales, Spain.
Boletin do Club Naval, Brazil.
Boletin del Centro Naval, South America.
Canadian Institute, Toronto, Canada.
Canadian Society of Civil Engineers, Montreal, Canada.
Deutsche Heeres Zeitung, Berlin, Germany.
Engineering, London, England.
Giornale d'Artiglieria e Genio, Rome, Italy.
Institute of Mining and Mechanical Engineers, London, England.
Institution of Civil Engineers, London, England.
Institution of Mechanical Engineers, London, England.
Journal de la Marine. Le Yacht, Paris, France.
Kongl. Orlogsmarma-Sallskapet, Carlskrona, Sweden.
Manufacturer and Inventor, London, England.
Mittheilungen aus dem Gebiete des Seewesens, Pola, Austria.
Mittheilungen des Vereins für Erdkunde zu Leipzig, Austria.
Mittler & Sohn, Berlin, Germany.
Norsk Tidsskrift for Sovaesen, Horten, Norway.
North-East Coast Institution of Engineers and Shipbuilders, England.
Revista de la Union Militar, Argentine Republic.
Revista Maritima Brazileira, Rio de Janeiro, Brazil.
Revista Militar, Santiago, Chili.
Revue du Cercle Militaire, France.
Revue Maritime et Coloniale, Paris, France.
Rivista Marittima, Rome, Italy.
Royal Artillery Institution, England.
Royal United Service Institution, England.
Société des Ingenieurs Civils, Paris, France.
Teknisk Tidskrift, Stockholm, Sweden.
The Engineer, London, England.
The Steamship, Leith, Scotland.
United Service Gazette, London, England.
United Service Institute, Sidney, New South Wales.

PUBLICATIONS ON HAND.

The Institute had on hand at the end of the year the following copies of back numbers of its Proceedings:

Press of The Friedenwald Co.
Baltimore, Md.

The writers only are responsible for the contents of their respective articles.

CONTENTS.

NOTICE.

ANNAPOLIS, MD., *February* 20, 1892.

Having carefully read the three essays submitted in competition for the prize offered by the U. S. Naval Institute for the year 1892, we have the honor to announce that, in accordance with Article XI. of the Constitution, the prize is awarded to the essay bearing the motto "Me, me adsum qui feci," on Torpedo-boats, their Organization and Conduct.

J. P. MERRELL,
Lieutenant-Commander, U. S. Navy,
R. R. INGERSOLL,
Lieutenant, U. S. Navy,
R. G. PECK,
Lieutenant, U. S. Navy,
N. M. TERRY,
Professor, U. S. Naval Academy,
J. K. BARTON,
Past Assistant Engineer, U. S. Navy,
C. M. KNEPPER,
Ensign, U. S. Navy,
H. G. DRESEL,
Ensign, U. S. Navy.
Members, Board of Control.

NOTICE.

It is earnestly desired that all MSS. of discussions on any articles in this number be forwarded to the Secretary and Treasurer not later than September 15, 1892.

By direction of the Board of Control.

H. G. DRESEL,
Ensign, U. S. Navy, Secretary and Treasurer.

THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XIV., No. 2. 1892. Whole No. 62.

PRIZE ESSAY FOR 1892.

MOTTO:—"*Me, me adsum qui feci.*"

TORPEDO-BOATS: THEIR ORGANIZATION AND CONDUCT.

BY WM. LAIRD CLOWES,

Associate and Honorary Fellow of King's College, London.

When the automobile torpedo first appeared as a possible factor in naval warfare, its value, like that of the majority of new and startling inventions, was generally misapprehended. The weapon, it was at first widely believed, would not only create novel conditions, but would also render vain and useless all the ancient principles by which warlike operations at sea had been previously conducted. Large craft of all kinds—the swift light cruiser and the slow heavy battleship alike—were to go down at once before the diminutive torpedo-boat, which, besides undertaking the scouting and commerce-destroying work that was of old performed by frigates, corvettes and sloops, was to bear a conspicuous part in the defense of coasts, harbors and estuaries, to do all the duties of the dispatch-vessel, to take a leading share in fleet-actions, and, in fine, to carry everything before it and to be irresistible.

It is not necessary here to enquire how these exaggerated ideas of the mission of the torpedo and the torpedo-boat arose; but it may fairly be suggested that the veil of mystery which by all the earliest users of it was thrown around the Whitehead torpedo did much towards fostering the misapprehensions. Even of the officers, only a select few were permitted to form any judgment of what the torpedo actually was. The rest, familiar merely with the outside of the weapon, were taught to regard it as a kind of fetish, the powers of which, if unknown, were also probably unlimited. In the British service, at that period, the amount of secrecy observed in connection with the Whitehead was, looking to the circumstances, positively amusing. Mr. Whitehead has always been quite willing to sell his torpedo—and so to convey its secret—to any state, corporation, or individual that may choose to pay the price demanded; yet whenever a torpedo had to be examined, cleaned or repaired on board a British man-of-war, a canvas screen was rigged up for the purpose, sentries were posted, and fully as much care was taken to prevent intrusion by the officers and men in general as could have been taken had a goddess been enjoying a bath upon the tabooed stretch of deck. In the meantime, the torpedo-boat was almost equally unfamiliar, save to a small class of specially trained people.

It is only natural that, amid such surroundings, the torpedo was misunderstood, and the torpedo-boat was systematically used for purposes for which it was in no way fitted. For several years during the British and French summer manœuvres, for example, the torpedo-flotillas accompanied the fleets to sea and were for long consecutive periods entirely dependent upon their larger consorts for shelter as well as for fuel and stores. Then came the reaction. Torpedo-boats were seen to be unsuitable for keeping the sea, and torpedoes, as they were run for practice, were observed to travel very inaccurately. It was, therefore, concluded—but too hastily—that torpedo-boats, not being able to keep the sea, must be almost useless; that no torpedoes were to be depended upon for accuracy; and that even if they were to be depended upon for accuracy, they could only be discharged with effect either from the shore or from ironclads and large craft. But fresh experiments were made; torpedoes and torpedo-vessels were greatly improved; and the pendulum of opinion, having thus swayed from one extreme to the other, now tends, in the absence of new disturbing influences, to gradually settle to rest at

some point between the two. It is the object of the following paper to discover, with the aid of such indications as have been afforded by torpedo-boat manœuvres, and by warlike operations in which torpedoes and torpedo-vessels have played a part, what that point is likely to be, and to show what are the true uses and limitations of the new naval arm.

The subject is not one that at present very nearly touches the United States, a country which scarcely possesses a torpedo-flotilla; but it is every day becoming more important; and in the unhappy event of the outbreak of a war, there would, I suspect, be more discussions about the handling of torpedo-boats, and more excitement about the exploits of them, than about the handling and exploits of craft of any other class. The torpedo-boat is essentially a vessel for a country with a long and deeply indented coast-line, with foreign ports not very far removed from her shores, and with historical traditions which render her more desirous of self-defense than of aggression. I think, therefore, that this paper is neither impertinent nor inopportune.

The modern automobile torpedo is a very different weapon from the Whitehead of six or seven years ago. How different it is can scarcely be realized save by one who has had the handling of both. The new one may fairly claim to be a weapon of precision; the old one—no matter what may have been its claims—was in reality nothing of the sort. Sometimes, when discharged, it traveled in a right line; oftener it did not. It was, moreover, slow, and it carried a comparatively small explosive charge. The latest Woolwich torpedo, on the other hand, is a triumph of light construction, speed, accuracy and power. Its engines, which are capable of developing fifty-two horse-power and making 2000 revolutions a minute, will drive it, up to 700 yards, at a speed of close upon thirty knots; and I have seen it travel in smooth water with fair speed and considerable accuracy as far as 1400 yards. As for its charge, it is so great that, if it be exploded in contact with the bottom of a ship, the vessel can scarcely fail to be put out of action. It may therefore be assumed that the modern automobile torpedo will do all the work that is expected of it, provided that it be properly prepared and properly discharged, that it be used at a reasonable range, and that there be no obstructions between the weapon and the target. Having assumed so much, it is not necessary to devote special attention to the torpedo itself. The more interesting question is: How best shall we bring the tor-

pedo into a position whence we may dispatch it, under all possible advantages, to do its work in war-time? And that is practically the question which I purpose to endeavor to answer.

But before making the attempt, I should premise that for several years I have enjoyed perhaps exceptional opportunities of seeing torpedoes and torpedo-boats at work under the conduct of those who are most familiar with the best types of both. I have witnessed the discharge of hundreds of unloaded torpedoes of all "marks" and designs, and of several loaded ones. I have watched experiments with all kinds of tubes, submerged and above water. I have been afloat in torpedo-vessels and torpedo-boats of all types and in all weathers. I have been present at numerous experimental torpedo-attacks, both by day and by night. I have observed the behavior of torpedo-boats under all conditions, and of their crews under all states of discomfort, excitement, danger and hurry. I have conversed or corresponded with the most distinguished torpedo specialists in Europe. And, finally, my experience has not been limited to the torpedoes and torpedo-flotillas of any one nation, and, though it has not of course extended to those of all countries, it has brought me into contact with several which admittedly rank among the best in the world to-day.

I have already said that in the early days of torpedo-boats they were regarded as proper accompaniments for a fleet at sea. In 1885, for example, when the British Particular Service Squadron, under Sir Geoffrey Hornby, manœuvred around the coasts of the British Islands, a squadron of eight torpedo-boats went with it, each boat being attached to an ironclad, and drawing from her the needful supplies of coal, water, stores and food. The boats were of the two following types:

	Displ. in tons.	Length.	Beam.	Mean Draught.	Extreme Speed.
6 of	32	87′ 0″	10′ 0″	4′ 0″	18 knots.
2 of	63	113′ 0″	12′ 6″	5′ 7″	20 knots.

At sea the boats were a failure; and, seeing that they met with some rather dirty weather, it has always been to me a matter of astonishment that they got back to their ports without serious disaster. They could sometimes make so little progress that they delayed even ships that had an extreme speed of no more than 10 knots; they were a continual source of trouble and anxiety to all engaged, and they were abodes of misery to those who were in them. On

the 9th and 10th of June, while steaming at a very easy speed on a calm sea, three of them broke down. On July 11, off the northwest coast of Ireland, in a brisk breeze from the westward, the senior officer in charge of four of the boats had to request permission to take them all inshore. And on July 17th and 18th, during half a gale in the Irish Sea, some of the boats behaved so badly that their crews, able neither to eat nor to sleep, and overtaken by most alarming sickness, were completely worn out and prostrated. What was attempted by England in 1885 was attempted by France in 1886, and in the following years by both nations. The British, having found that their 113 ft. boats were not sea-keepers, tried 125 ft., 127½ ft., and 130 ft. boats. The French tried an even greater number of types, ending with the 151 ft. boats of the Ouragan class. But long before the series of experiments had been carried far, it was pretty generally recognized that the torpedo-boat, as distinct from the torpedo-boat-catcher or torpedo-gunboat, was unsuited for keeping the sea; and that if sea-keeping torpedo-vessels were required, they must be of 250 tons' displacement at least, and might, with advantage to the comfort and condition of their crews, be considerably larger. This conclusion had the effect of creating a new species of small craft, midway between the torpedo-cruiser and the torpedo-boat. To the new craft, the torpedo-gun-vessel, has been assigned most of the work which, it was originally supposed, the torpedo-boat was capable of; and the torpedo-boat, being no longer needed to serve as a scout and dispatch-vessel, fell into some neglect until her merits and her potentialities were developed in a new direction, first to a slight extent by the Germans, and then, especially during the naval manœuvres of 1890, by the British.

What may be called the new view of the proper functions of the torpedo-boat regards that little craft as merely a quick and decisive raider from a base, and not as a vessel from which any kind of sustained effort must be demanded. The torpedo-boat's business is to strike, like a bolt from the blue, in the most unexpected quarters; to be always in perfect readiness for a few hours of rough hard work under extreme pressure; to appear unannounced in distant places; to vanish unpursued and unseen; and never to expose herself unnecessarily either to the violence of the sea or to the attention of the enemy. Yet this new view—which is, I am persuaded, the right one—is not yet exclusively adhered to anywhere. In Germany, during the combined manœuvres of 1890, I saw torpedo-boats in the Nübel-

Noor engaged in an entirely inappropriate artillery duel with the field batteries of the Ninth Army Corps. At Kiel, in 1891, other boats made an attempt to rush past forts which were already alarmed and expecting the attack. And, during the British manœuvres of 1891, boats were on several occasions kept too long at sea, so that their people were unduly fatigued; and they were, moreover, so handled that they were never properly withdrawn from the enemy's observation, and were, in consequence, never in a position to deliver a real surprise attack. It was in the British manœuvres of 1890 that the rudimentary principles of the new view were most consistently acted upon; and although the story of the raid from Guernsey upon the fleet at Plymouth has been told more than once, I must here tell it again, if only because that raid seems to me to mark the beginning of a new departure which may some day lead to startling results.

During the British naval manœuvres of 1890 hostilities began at 5 p. m. on the 8th of August. At that hour the positions of the squadrons, so far as they need here be considered, were as follows:

A. Within Plymouth Breakwater. The battleships Northumberland (flag), Anson (flag), Rodney, Inflexible, Invincible, Triumph, Hotspur, Black Prince, and Hero. The armored cruisers Narcissus, Galatea, and Shannon. The cruisers Iris, Thames, Mersey, Medusa, Inconstant, Mohawk, and Racoon. The special-service vessel Hearty. The sloop Basilisk. The torpedo-gun-vessels Speedwell and Spider.

C. At the Channel Islands. The first-class torpedo-boats:

No.	Displ. in tons.	I. H. P.	Length.	Beam.	Mean Draught.	Extreme Speed.
51	64	700	127′ 6″	12′ 6″	6′ 3″	20.5 knots.
55	64	700	127 6	12 6	6 3	20.5 knots.
57	64	700	127 6	12 6	6 3	20.5 knots.
58	64	700	127 6	12 6	6 3	20.5 knots.
59	64	700	127 6	12 6	6 3	20.5 knots.
81	125	1387	150 0	17 6	7 4	20.7 knots.
82	95	1160	130 0	13 6	7 0	22.5 knots.
86	95	1160	130 0	13 6	7 0	22.5 knots.
87	95	1160	130 0	13 6	7 0	22.5 knots.

Sir George Tryon, commander-in-chief of Squadron A, was not permitted, under the rules of the manœuvres, to proceed with his fleet to sea until 5 p. m. on the 9th of August. Being apparently uncertain whether this restriction tied the hands of the senior officer of the opposing Squadron C, as well as his own hands, he, at a quarter

past eleven p. m. on the 8th, made the general signal, "Although I consider my hands tied as yet, still we are at no great distance from torpedo-boats; therefore keep a good lookout and have a few guns ready."

This signal was a very injudicious one. Hostilities had commenced and the enemy was at liberty to act when he would. But if there had been the smallest doubt in his mind upon the subject, Sir George should have signaled either: "According to my reading of the rules, no attack is legitimate to-night, and therefore torpedo-boats are not to be treated as enemies." Or: "Although, according to my reading of the rules, no attack is legitimate to-night, there is likely to be one, and all suitable measures must be adopted to ward it off and to repel it." The injunction "have a few guns ready," while it prevented the Admiral from afterwards claiming that he was not prepared, was a half-hearted order. It may perhaps seem frivolous to discuss the matter here, yet, since it is yearly growing more and more obvious that even when there is only the remotest risk of war, no possible precautions should be neglected, it is, I venture to think, worth while calling attention to it. All else that Sir George did was to send three cruisers to scout in the chops of the Channel, without special reference to the force at the Channel Islands.

The torpedo-boats "at no great distance" were at Guernsey, which, as the crow flies, is about 100 nautical miles from Plymouth Breakwater. Having regard to the state of the sea at the time, the distance may be considered as equal to between six and seven hours' steaming at the boats' best attainable speed. The senior officer at Alderney was Commander H. D. Barry, who, I believe, called to his counsel Lieutenants F. C. D. Sturdee and Lionel de L. Wells. I mention the names because to these officers entirely belongs the credit for what was done.

Commander Barry, whose headquarters were at Alderney, had already determined to attack Squadron A at its anchorage as soon as possible after the beginning of hostilities, and he planned two successive onslaughts: one, under Lieutenant Wells, to be made by Nos. 82, 86 and 87; and the other, to be delivered two hours later, under Lieutenant Sturdee, by Nos. 51, 55, 57, 58, 59 and 81.

I was on board one of the ships of Squadron A, and, being fully convinced that an attack would take place, did not leave the deck after about eleven o'clock p. m. The battleships and cruisers lay in four lines, at a distance of two cables, parallel with the breakwater,

the line nearest to the breakwater being composed of the Northumberland, Rodney, Anson, and Black Prince. The other big ships, except the Narcissus, Galatea, and Iris (which had been dispatched to the westward at half-past nine), formed the remaining three lines, and the small craft lay by themselves in Cawsand Bay. No vessels had their nets down; there were no search-lights in use on the breakwater or elsewhere; there were no booms, obstructions, or mine-fields at either entrance to the Sound, and there were neither cruisers nor picket-boats specially watching for the torpedo-boats which were "at no great distance." On the other hand, there was a good lookout, "a few guns" were ready, and the night was clear and light.

Lieutenant Wells, who had been lying with his division at St. Peter Port on the east side of Guernsey, started at a little before 6 p. m.—as soon, that is, as the declaration of war had reached him. Proceeding at between 16 and 17 knots and in open order, he sighted the Start Light before midnight, and soon afterwards increased speed to 19 knots. Shortly after 2 a. m., in column of line ahead, he entered the Sound by the eastern entrance, next to which lay the Black Prince. The torpedoes for use were provided with collapsible heads of soft copper. On both sides the official arrangements for timing were very bad, and this fact naturally led to considerable conflicts of evidence as to what occurred: but my own observation convinces me that the boats were not sighted from the ships until they were all within the breakwater, and that, from the moment of the firing of the first gun to the moment when the last of the boats had discharged her torpedo, barely two minutes elapsed. As I had only an ordinary watch, I do not pretend to have been able to measure by seconds. It should here be noted that the rules placed the boats at no small artificial disadvantage. Firstly, although each boat had three tubes, and could have fired three torpedoes almost simultaneously, she was permitted only to fire one. Secondly, after firing, she was required to remain on the spot to pick up her weapon, thus getting in the way of the boat astern of her.

Owing to the conflict of evidence, no claims on either side were allowed by the umpires; but No. 86 claimed the Black Prince, and No. 87 claimed and admittedly hit the Invincible. The Black Prince denied that she had been struck; but the Anson, which was not claimed, was admittedly struck—possibly by the torpedo that was meant for the Black Prince, her next ship. No. 82's torpedo, aimed, like that of No. 86, at the Black Prince, had a leaky air-chamber

and failed to run. No. 82 then collided with the Black Prince and was so damaged as to be unfit for further sea-work, though she might still, of course, have discharged her second and third torpedoes at the ships around her.

So much for the bare facts of Lieutenant Wells' attack. Limited though the torpedo-boats were in their operations, there is in my mind very little doubt that they are now entitled to claim that they put out of action the first-class battleship Anson and the second-class battleship Invincible; which two vessels represented at the time an expenditure of very nearly 5,900,000 dollars, and had on board over 1000 officers and men. Supposing the whole of the attacking force to have perished, less than 300,000 dollars and only 57 lives would have been thrown away. And it is worthy of consideration that while new torpedo-boats may be built in three months, new battleships require three years. On board the ships there was, if not confusion, at least lack of system. Guns were fired long after the smoke of previous discharges had effectively shrouded the moving boats; and although it was a light night, the search-lights, which might have been very well dispensed with, were turned on and flashed hither and thither without much method, until one's eyes were unable to distinguish anything. As an eye-witness wrote next day: "It was fairly easy to follow the motions of the daring little craft until the ships, by signal from the Admiral, turned their electric-lights on. Thenceforward all was doubt and confusion, for there is nothing more perplexing than the flashing of search-lights at night." I feel sure that the influence of the lights must, upon the whole, have been as favorable to the attack as it certainly was unfavorable to the defense; and had the boats been permitted to discharge three torpedoes apiece, instead of but one, I see no reason why they should not have effected three times as much damage as they did effect.

Lieutenant Sturdee left his anchorage at, I believe, about 7 o'clock, and, steaming more slowly than Lieutenant Wells, entered the Sound by the western entrance at a little before 4 o'clock. He kept well under the land above Cawsand Bay, and was to some extent further sheltered by one or more large steamers that were going out; but, on the other hand, the defense, knowing that three boats only had attacked with the first division, and that many more were at Commander Barry's disposal, was now—or at least should have been—perfectly prepared. Nevertheless, No. 81 torpedoed the

Northumberland within a minute of the firing of the first gun. No. 58 did the same with the cruiser Inconstant. No. 57 discharged her weapon at the Invincible, but it failed to run. No. 59 aimed at the Northumberland, but missed her and struck No. 51, which seems to have meanwhile torpedoed the already damaged Inconstant. The sixth boat, No. 55, was troubled with hot bearings ere she could enter the Sound, and, attacking independently through the eastern entrance, was discovered by a guard-boat. Her commander declared that guns were fired and search-lights turned in every direction save that of his craft, and that his torpedo struck the Invincible. I saw this attack and am inclined to agree with him. Admitting, therefore, such claims as I conceive to be well-founded, I add the third-class battleship Northumberland and the second-class cruiser Inconstant to the number of A's ships put *hors de combat*, and, assuming that even all the torpedo-boats perished in the two affairs, place the total bill of damage for the night's work at:

	A's Losses. Value Dollars.	Men.		C's Losses. Value Dollars.	Men.
Northumberland	$4,030,000	688	Nine Torpedo-boats,	$900,000	163
Anson,	3,625,000	524			
Invincible,	2,270,000	482			
Inconstant,	2,275,000	608			
	$12,200,000	2,302		$900,000	163

The umpires, confused by the contradictory nature of the numerous accounts, and unable to solve the difficulty in any other manner, declined to give any decision upon the claims of either side; but they did say, in their report, that "the tactics of the torpedo-flotilla operating from Alderney, as a distant base, were well planned and efficiently carried out during the early part of the manœuvres, notably in the attack upon A fleet in Plymouth Sound on the night of the 8th–9th of August."

Another instructive series of torpedo-boat manœuvres was carried out in British waters in the summer of 1891. They were, it appears to me, far less ably planned than the operations which I have just described, but, in some points at least, they were even more suggestive. I give them, as before, from notes made at the time.

War between the Red and Blue Squadrons was declared at noon on Wednesday, July 22. At that hour the disposition of the hostile forces was, I believe, as follows (see following page):

RED SQUADRON.

Armored Vessels.	Displ. in tons.	Armament.	Estimated Sea Speed.	Men.	
Shannon	5390	2–10 in. M. L.; 7–9 in. M. L.; 10 Q. F. and M	10.5 K.	446	at anchor, Dale Roads, Milford Haven, with nets out.
Hotspur	4010	2–12 in. M. L.; 2–6 in. B. L.; 13 Q. F. and M	10.0 K.	233	
Northampton	7630	4–10 in. M. L.; 8–9 in. M. L.; 4–4.7 in. Q. F. 24 Q. F. and M.	11.5 K.	569	
Unarmored Cruiser.					
Barracouta	1580	6–4.7 in.; 6 Q. F. and M	13.5 K.	156	Dale Roads, Milford Haven, ready to proceed to sea.
Torpedo Gun Vessels.					
Seagull	735	2–4.7 in.; 4 Q. F	16.5 K.	86	
Spider	525	1–4 in.; 6 Q. F.	15.0 K	63	
Skipjack	735	2–4.7 in.; 4 Q. F.	16.5 K.	86	
Gossamer	735	2–4.7 in.; 4 Q. F.	16.5 K	86	
Rattlesnake	550	1–4 in.; 6 Q. F.	17.0 K.	63	

BLUE SQUADRON.

Torpedo-depot ship Hecla and 3 first-class torpedo-boats, at Carrickfergus.
Special-service vessel Magnet and 2 first-class torpedo-boats, at Carlingford.
Battleship Belle-isle and 3 first-class torpedo-boats, at Kingstown.
Special-service vessel Traveller and 3 first-class torpedo-boats, at Wicklow.
" " " Hearty and 3 " " " " Wexford.
Torpedo gun-vessel Curfew and 6 " " " " Waterford Harbor.

The "Blue" torpedo-boats were Nos. 25, 33, 42, 45, 52, 53, 55, 57, 58, 59, 60, 65, 67, 73, 74, 75, 82, 83, 84 and 85. The vessels with them were stationary.

The Red Squadron was under Captain S. Long, who flew a broad-pennant in the Barracouta; the Blue was under Rear-Admiral Erskine, senior officer at Queenstown, Capt. J. Dunford, of the Hecla, directing operations afloat, and Commander Barry, the projector of the raid upon Plymouth Sound, being in the Curlew.

In the leading idea, England and Scotland, within certain limits which it is unnecessary here to define, were supposed to be at war with Ireland. To the former belonged the Red and to the latter the Blue Squadron. Red's armored vessels were taken to represent a fleet of battleships which was awaiting opportunities to annoy Blue's ships and coasts. Blue's flotilla was taken to be a hostile force which might be expected to repeat against Red the tactics which had been essayed in 1890 from the Channel Islands against Sir George Tryon at Plymouth, and which, also, would endeavor in every possible way to thwart whatever designs might from time to time occur to the Red commanding officer. To Red's light craft were entrusted such duties as would naturally fall to the lot of cruisers, scouts and dispatch vessels in war-time. Blue's heavy craft were to do the work merely of guard-ships and depôt-ships.

Seeing that, at the time of writing, the official report of the umpires has not been made public, I am obliged to trust exclusively to my own observation for a knowledge of what occurred. This, according to my diary, as kept from day to day and as amplified from information obtained at the time from officers concerned, was briefly as follows:

Wednesday, July 22. The Red small craft left Milford Haven to scout in the Channel.

Thursday, July 23. Early this morning they returned, claiming to have taken or sunk in the offing eight Blue torpedo-boats which had been prowling about outside. At 6 a. m. the ironclads, having taken in their nets, weighed and proceeded to sea from Dale Roads. A few hours afterwards nine Blue torpedo-boats made a raid into Milford Haven, but found the quarry gone.

Friday, July 24. This morning the Red Squadron appeared off Kingstown, and for four hours fired at the Belle-isle, which lay behind the pier with her guns masked by it, and which was then claimed as destroyed. The Red Squadron thereupon headed for Belfast.

Saturday, July 25. At 12.20 a. m., while the Red Squadron was still on its way under easy steam to Belfast, torpedo-boat No. 74 approached the Northampton, which was last in the line, and discharged a Whitehead, which struck the ironclad on the port quarter, but not until the boat had been under fire for at least four minutes. The umpires, who were appealed to by telegraph from both sides, adjudged the boat to have been out of action when she launched her torpedo. Arrived in Belfast Lough, the squadron found that the Hecla had laid down extensive mine-fields to protect herself. It was deemed inadvisable to risk the ships or waste time, and the squadron withdrew to Luce Bay, Wigtonshire, where it anchored at 2 p. m., got out its nets, and sent out its small craft to scout.

Sunday, July 26. At 2.15 a. m. torpedo-boats Nos. 42, 25 and 55 attacked, having crept under the land and so got inside the Red Squadron. No. 42 discharged a Whitehead, which missed the Hotspur, the center ship of the line, and, almost spent, ran gently into the Northampton's nets. At 3 a. m. No. 83 attacked, discharging at the Northampton a torpedo which failed to run.

Monday, July 27. At 12.43 a. m. torpedo-boat No. 25 entered the bay, under the land, rounded the Northampton's bow, came down on the starboard or land side, and discharged a Whitehead which failed to run. At daybreak nets were taken in, and at 8 a. m. the squadron steamed south.

Tuesday, July 28. While the squadron was at sea in the early morning two torpedo-boats came up astern. One did not press the attack, but withdrew on being fired at. The other approached and attempted to torpedo the rearmost ship on the port quarter, but the Whiteheads failed to run. At 2.45 a. m. a third boat came up astern, but withdrew on being fired at. At 9 a. m. Wicklow was reached, and by 1 p. m. the Traveller, which was found there, had been put out of action by the guns of the ironclads. The squadron then steamed to Milford Haven.

Wednesday, July 29. At 9.30 a. m. the Red Squadron anchored in Milford Haven, in its former anchorage, and got out its nets, while the small craft scouted in the offing.

Thursday, July 30. At 1.30 a. m. two torpedo-boats attacked the Shannon and Hotspur, but did not strike them and were put out of action. At 3 a. m. a third boat, No. 45, attacked the Northampton from astern and fired a torpedo, which, however, did not touch the nets. At 12 a. m. hostilities ceased.

The usual formation, while the Red Squadron was at sea, was with the three armored ships in column of line ahead, and with the light craft disposed around them, ahead, astern and on the beams, at distances of about 10 cables. The important and suggestive points to be borne in mind in connection with the operations are: (*a*) that none of the torpedo attacks were completely successful; (*b*) that, out of eight torpedoes discharged, three failed to run; three ran but failed to hit anything; one ran, missed its aim and hit something else, but did not hit it until the impulsive force had been expended; and only one ran, hit what it intended to hit, and (save that the boat which discharged it was already theoretically out of action) did its appointed work; (*c*) that every torpedo attack that was made against the ships while they were under steam was made from astern; and (*d*) that all the attacks made against ships at anchor were altogether fruitless, while the only one which met with even comparative success was made at sea. All the attacks were, by the way, made during the night.

I must cite two other examples of the use or abuse of torpedoes and torpedo-boats. I shall then have referred to all the most important of my "leading cases," and shall be free to point out the lessons which it seems to me are to be derived from them and from others.

I have heard it said over and over again that the sinking of the Blanco Encalada teaches no lessons, and I have as often disagreed. It is, I submit, in some respects the most significant leading case we have. I was not upon the Chilian coast at the time, but I have before me the official dispatches from both sides, and, better still, an account which has been kindly prepared for me by my friend Capt. St. Clair, late of H. British M. Ship Champion, which was upon the coast. This account includes the substance of a report that was rendered by the Champion's gunnery lieutenant, Mr. R. B. Colmore, who, with the aid of divers, thoroughly examined the Blanco Encalada two days after she was sunk.

The Blanco Encalada arrived in Caldera Bay on April 22d with several transports in company, and at once landed a force which left by railway to take possession of Copiapo. Captain Goñi, of the Blanco, commanded the force, and, after Copiapo had been occupied, returned to Caldera, boarding his own ship at about 1.30 a. m. on the morning of the 23d. In his absence no fears of any attack were entertained and no precautions had been taken.

The ship was lying at a buoy in the southern part of the bay, with steam ready for moving the engines, and with the ordinary guard of seven men on watch. The armament of rapid-firing and machine guns had been reduced to admit of arming the transports, and at the time the ship had three 6-pr. R. F. Hotchkiss guns, disposed one on each side of the forecastle and one on the poop; four 1-inch Nordenfelts, disposed one on each side of the fore-bridge, one on the after-bridge, and one on the starboard side of the poop; one Hotchkiss R. C. in the top; and two .45-inch machine guns. Her original complement had been 300 well-trained men, but of these only 80 remained on board, the rest having been drafted to other vessels or landed with the Naval Brigade, and their places having been taken by raw recruits who had small knowledge of their duties, or even of a ship.

The Almirante Lynch and Almirante Condell were commanded by Captains Moraga and Fuentes, both of whom had received torpedo training at the Torpedo School in Valparaiso under Captain Santa Cruz; and they had the services of an experienced French torpedo artificer who had recently arrived from Europe to repair and adjust torpedoes for the Chilian government. The armament of each consisted of three 14-pr. R. F. Hotchkiss guns, disposed two on the forecastle *en échelon* and one on the poop; four 3-pr. R. F. Hotchkiss guns, disposed two on the poop and one on each beam or sponsons; and five torpedo-tubes, disposed one ahead and two on each beam. The torpedo-gun-vessels left Valparaiso on the 18th, and spent part of the 18th and the whole of the 19th and 20th in Quinteros Bay, and started northward again on the 21st, arriving off Huasco at two o'clock on the afternoon of the 22d. There they remained until after 5 p. m., probably, as would appear from Captain Moraga's report, until about 6 p. m. Quinteros is, roughly speaking, 400, and Huasco 100, miles from Caldera; so that, if up to 6 p. m. on the evening of the 22d the Congressionalists at Caldera had been informed of the whereabouts of their enemies, they would have known them to be 100 miles away. There seems to be no reason for supposing that they had any knowledge that the foe had come north from Valparaiso at all.

Caldera Bay opens to the northwest. Instead of entering round the southern promontory on which stands the lighthouse, the attacking force appears to have kept away until well beyond the northern promontory, and to have then turned and entered on that side. Says Captain Moraga:

"Shortly before 4 o'clock in the morning (of the 23d) I entered Caldera Bay. So far as the moonlight permitted, I reconnoitred the position of the revolutionary vessels from the bridge. In the meantime the Lynch followed in my wake at a distance of about 50 meters. When I had discovered the positions of the vessels I retired at half-speed directly for the Blanco or Cochrane, for at that moment I did not know which of the two ships was before me. Behind the after-part of the ironclad I distinguished another vessel, which from her outline I took to be the Huascar. At a distance of about 100 meters I discharged a bow torpedo, which missed and, almost grazing the stern of the ironclad, probably struck the ship which lay close to her. Immediately after this first shot I turned to starboard, and at about 60 meters fired one of the port torpedoes, which must have struck the forward part of the ship attacked. Almost simultaneously I ordered Lieutenant Rivera to let go the second torpedo on the same side. Between the second and third discharges the ironclad opened fire upon my ship with great quickness and spirit from mitrailleuses, rapid-firing guns and small-arms. After my ship had discharged her first torpedo I ordered full speed ahead. The fire of the ironclad remained concentrated on the senior officer's ship, and they did not notice that the Lynch, which had followed the motions of the Condell, placed herself at very short range and fired her bow torpedo, which missed. Turning to starboard, the Lynch discharged her second torpedo, which struck the Blanco somewhere amidships. Two minutes later the revolutionary ship sank. From the discharge of the Condell's first torpedo to the discharge of the Lynch's second, about seven minutes elapsed."

The account obtained by the Champion's officers from Captain Goñi and other survivors is as follows:

"The morning was dull and cloudy, the moon at intervals being completely obscured. At about 4 a. m. the torpedo-vessels were sighted by the lookout men at a distance of about 2000 yards. The alarm was at once given, but some delay took place in getting the people to their quarters, owing to the bugler mistaking the orders and sounding the ordinary reveille instead of the call for action. By this time the torpedo-vessels had approached within 500 yards on the starboard bow, and fire was opened on them from R. F. and machine guns. This was at once returned, the Condell at the same time discharging her bow torpedo, which passed ahead of the ironclad and, running on shore, exploded there. The vessels then

appeared to stop their engines. Orders were given on board the iron-clad to slip the cable and go ahead with the port engine and astern with the starboard, but these orders do not seem to have been carried out. The Lynch then went full speed ahead, passing along the starboard beam and discharging both tubes at a distance of about 100 yards. One torpedo struck the Blanco and exploded. That vessel slowly heeled over and sank in less than five minutes. She first fired one of her heavy guns, but the shell passed over the Lynch without damaging her, and the latter passing under the Blanco's stern, discharged her bow torpedo at the transport Biobio, which lay inside, but without effect. The torpedo is said to have passed underneath the transport. The torpedo-vessels then steamed out of the bay, apparently uninjured."

The discrepancies between the two accounts are remarkable, but perhaps not greater than should, in the circumstances, be looked for. Nor do they affect the conclusions, which are, that the Blanco Encalada was surprised and destroyed, and that her assailants got away from her practically scot-free. Torpedo practice and gun-fire seem to have been alike execrable.

My last leading case is that of the attack on the armed transport Aconcagua. This is what Captain Moraga, of the Condell, has to say about it:

"As we drew off from Caldera we fell in with the transport Aconcagua, which was coming from the southward as if to enter the bay. As soon as she recognized us she endeavored to get away, turning to seaward and at the same time opening fire on us. When the revolutionary transport perceived that, on account of our superior speed, retreat was hopeless, she again headed for Caldera, possibly in expectation of there sighting her consorts and being assisted by them. She was at once engaged by the two torpedo-vessels in an action which lasted for an hour and a half. During this period the fire of the Lynch and Condell silenced that of the Aconcagua and forced that ship to stop her engines. She did not strike, for she fought without her flag. At the crisis of the action there appeared on the horizon smoke, which I imagined to proceed from the Esmeralda; and, in addition, several tubes in one of my port-boilers exploded and obliged the engineers for a few moments to leave their employment in that compartment. In consequence of these occurrences I headed to the southward and ordered the Lynch to permit our prey to depart. Soon afterwards I discovered that the vessel which had been sighted

was the ironclad Warspite of the English Navy. She seemed desirous of entering the harbor. The Aconcagua took advantage of the situation to head with all speed for Caldera and to place herself under the protection of the forts."

The official account of Captain Merino Jarpa, of the Aconcagua, puts a different complexion upon the action. It runs:

"At seven o'clock on the morning of the 23d of April it was reported to me from forward that the torpedo-vessels Lynch and Condell had been sighted off Morro Copiapo at a distance of about 7000 meters (about 4½ miles). I at once ordered the vessel to be headed in that direction, caused 'clear ship' to be sounded, and increased my speed. When I was about 4000 meters from them I opened fire from my rapid-firing guns. This was immediately returned by both vessels with great rapidity and promptness. So incessant was the discharge that it resembled that of small-arms rather than that of guns. At first they separated, as if to place us between two fires, but they soon altered their intentions, possibly because the manœuvre would have enabled me to use the guns on both broadsides. Both put themselves on our port hand. At this time one of them was struck by a shell and emitted such quantities of smoke and steam that for a period of two minutes she was completely invisible to us. Her speed, from this moment, sensibly diminished, and she fell away on the Aconcagua's port quarter, while the other craft kept parallel with us at a distance of from 1500 to 2000 meters. As this position did not permit me to use all my guns, I turned and headed the Aconcagua for the latter ship, and so was able to bring two of my 13-cm. (5.1″) guns into action. Upon this the torpedo-vessel increased her speed and withdrew, keeping away to seaward. The action began at seven and ended at twenty minutes past eight in the morning. During that time we fired without intermission 197 rounds, including 7 from the 13-cm. guns. The rest were from the rapid-firing guns, with a few from the Hotchkiss mitrailleuse. The Aconcagua's speed throughout the action was 11 knots. Out of more than 400 projectiles which the enemy fired from his rapid-firing guns eight only struck this ship, and these hit the woodwork above the waterline and did but little damage to the vessel and her crew. We had four slightly wounded. . . The action confirms the opinion that torpedo-vessels are useful only for unexpected attack. The view that they are worth nothing as fighting craft will perhaps be shared by the naval officers of the Dictator when they

reflect that during a ninety minutes' hot conflict they could gain absolutely no advantage over a simple merchant-steamer whose classification as a man-of-war is based solely upon the fact that she happens now to carry a few guns of small calibre. From this it results that torpedo-vessels are lost from the moment when they encounter a real man-of-war, if only she can bring them to action."

Captain Jarpa's conclusion that torpedo-vessels are useful only for unexpected attack seems to me to be fairly supported by all the examples which I have cited, and by the majority of the other examples which I might cite. The successful attacks on the Housatonic and the Albemarle, during the war of Secession, were surprises; the Russian torpedo-attack off Batoum on the night of May 12th-13th, 1877, was a surprise, and, but for an accident, would have been successful; the successful attack, a fortnight later, on the monitor Seifi, off Matchin, was a surprise. On the other hand, the exceedingly gallant daylight attacks of June 20th and 23d, 1877, off Rustchuk and Nicopolis respectively, were costly failures. In the same year the Huascar, attacked with a Whitehead by the Shah, evaded the projectile by accidentally or intentionally altering course; and in 1885 the Polyphemus, during the Bantry Bay operations, easily escaped several Whiteheads which were aimed at her, she being able to see them, and having sufficient speed and turning-power to outmanœuvre them. Indeed, I can think of no case in which, either in peace or in war, a torpedo-attack, unless made in darkness or as a complete surprise, has attained its object, or would, but for accidental circumstances, have attained those objects.

Secrecy and suddenness, then, are desiderata of prime importance for the success of a torpedo-attack. Equally important are organization and training. The descent upon the fleet at Plymouth was made with sufficient secrecy and suddenness; but neither the organization of the flotilla nor the training of the ship's companies engaged was what it should have been. An officer who took part in the affair lamented to me that Lieutenant Sturdee's division of six boats was too large to admit of being properly kept in hand by a single commander, and another officer informed me that many of the lieutenants in command of boats had gone on board without proper instruments for the navigation of their craft in case of the separation of the flotilla; that the engine-room complements were not familiar with the machinery, and that the discharge of the torpedoes took place in some cases with undue haste and flurry.

These were the naturally resultant faults of incomplete organization and training. Similar causes led, no doubt, to the large number of failures to run during the British manœuvres of 1891, and to the numerous misses and failures of the Chilian war. One has heard of torpedoes having been fired before they have been tested for flotability, and even before they have been charged with air; and I myself have seen a torpedo picked up with its water-tripper jammed in such a way that it could not possibly act. Accidents, oversights and follies may always occur in connection with operations like those which are now under consideration, but system will reduce to a minimum the liability to any of these, and I shall devote the rest of this paper to the advocacy of the system of peace organization, training, and war-tactics which appears to be logically suggested by the experience of the past.

In order to be able, in war-time, to properly utilize torpedo-boats for a descent such as was made upon Plymouth in 1890, a naval power should, I am convinced, keep the greater part of its torpedo-flotilla perpetually in commission. I do not mean that each boat, where there are considerable numbers of boats, need be kept in full commission with, as in the British Navy, her lieutenant, one or two sub-lieutenants, and a gunner or boatswain on board. But the engine-room staff, since it can never know too much about the boilers and machinery, should be always attached to the craft, and should be given frequent opportunities of perfecting acquaintance with its delicacies and its peculiarities. The executive and navigating staffs require no such special and intimate knowledge. One torpedo-boat may be navigated and fought very much like another. Her idiosyncrasies—or, at least, her important ones—reside entirely in her boilers and machinery. While, therefore, each boat, if she is to be employed to the greatest advantage, must have an engine-room staff that is thoroughly accustomed to her, any competent navigator or any competent executive-officer would serve almost as well as one who had been born and bred on board. It would be enough, in ordinary peace-time, to place a trustworthy warrant-officer in charge, and to leave him there as second or third officer upon the full commissioning of the boat for manœuvres of war.

But a single boat would never, for any purposes, be regarded as an independent unit. What the unit in torpedo-warfare should be is still, in Europe, a matter of discussion. In infantry tactics the battalion is the unit; in artillery tactics it is the battery; in torpedo-

boat tactics it must be the division; but battalions and batteries are not in all armies of the same strength, nor even in particular armies are they always invariable; and the same is the case with torpedo-boat divisions. The German division, for example, consists of six first-class boats and a "division boat"—a vessel of three or four hundred tons' displacement, of great speed, and of characteristics generally resembling those of the "avisos-torpilleurs" of the French navy, or of the "torpedo-gun-vessels" of the British. In England the division has contained six, four, or three boats, with or without a torpedo-gun-vessel attached. In France, also, the constitution of the division varies, or has varied. Professional opinion now, however, seems to incline in most countries in the direction of the division of three boats, with, if possible, a larger craft to carry the divisional commander, to lead the navigation, to undertake the repair of small defects, to provide supplies of water, coal and stores, and in short to act, for brief periods, as a small *mere cigogne* to her consorts. Where three boats to the division are not advocated, two appear, save in Germany, to meet with more favor than four, and four with more favor than five or any greater number. British officers of experience, almost with one accord, advocate three, with a larger craft; and I shall confine myself to the consideration of the division as thus constituted; for I believe it to be far and away the best.

The peace "state" of such a division would include a full complement for the larger craft (which would be commanded by a lieutenant; with a lieutenant for navigating duties; a sub-lieutenant or ensign, a chief engineer, a surgeon, and subordinate officers under him), and reduced complements (consisting only of a warrant-officer and engine-room staff) for each of the three boats. The divisional commander would thus have at his disposal sufficient officers and men to enable him to keep his division in good order and training, and to continually exercise part of it along the coast in the neighborhood of his headquarters. But he should by no means be the sole director of its operations. An officer of a superior rank (a lieutenant-commander, commander or junior captain) should be appointed to a small cruiser or gun-vessel as inspecting officer, and should be empowered and required to visit all divisional headquarters unannounced, and, by day or by night, to mobilize the divisions, manning them up to full war complement from the ship's company of his own vessel, and then exercising them at manœuvres at full speed. If, for example, a division had its headquarters at Newport, R. I., an

inspecting officer arriving there unannounced by night would teach valuable experience to the command by mobilizing and dispatching it in all haste to Nantucket or to New Haven, Conn., and back. The celerity, ease and absence of mishaps with which the operation should be carried out would to a large extent measure the efficiency of the division for the kind of work to which it would be put in war-time.

And here I may fitly state some of the arguments in favor of adding a "division-boat" or torpedo-gun-vessel to each division. Every one who has had much experience at sea in torpedo-boats knows how very limited is the horizon from the low deck of so small a craft, and how difficult—especially in bad weather—is the navigation of her. A vessel with a mast of some kind, and with a proportionately wider horizon, can keep a far better lookout than any torpedo-boat, and so avoid dangers that the torpedo-boat may easily fail to discover until she is close upon them. Again, the larger vessel being roomier and steadier, can take observations and conduct navigation with much greater facility than the smaller one, and may, in fact, "make" the navigation for her consorts when they cannot readily make it for themselves. But this is by no means all. The inevitable delicacy of torpedo-boats renders them particularly liable to slight but not insignificant damage by collision and other accidents. A "division boat" can carry appliances for the remedy of innumerable small defects either in hull or in machinery. She can also tow a more seriously injured craft; render effective help to the crew of a foundering one; serve as hospital to her division; make a lee for the protection of her little consorts; shield them, until the critical moment, from the observation of a careless enemy; cover them with her guns, and render them a thousand small offices of value, besides inspiring them generally with confidence.

So numerous are the advantages attendant upon the presence of a division-boat with the division that, in my humble opinion, a division should as seldom as possible be employed without such a leader; but circumstances will in war-time of course occasionally arise to render impracticable the combined operation of a whole division as thus constituted. For example, there may be a scarcity of vessels. This cause would, for the present, stand in the way of the formation of regular divisions in the United States and in some other countries. And it might, in certain contingencies, stand in the way of the formation of regular divisions even in those countries which are

best provided both with torpedo-boats and with torpedo-gun-vessels; for it is easy to conceive that, in the event of hostilities between a very strong naval power and a comparatively weak one, the naval ports of the latter might be so carefully watched as to make it hopeless for a regular torpedo-flotilla to issue from them with any prospect of being able to deal a sudden blow. Single vessels might escape and take refuge temporarily along the coast until they saw their opportunity to strike, but they might be unable to arrange any combined attack and might be reduced to operating independently. This would deprive them of much of their value; and therefore I confidently anticipate that in the next war, wherever it may occur, means will be devised to facilitate the concentration and combined action of torpedo-boats in spite of any system of observation or actual blockade that may be established by the enemy.

Devices of this kind would not facilitate the co-operation of division-boats, save in countries which are exceptionally well provided with a network of canals of some depth; but they might, in all civilized countries, ensure the complete mobility of torpedo-boats not exceeding about fifty tons displacement.

Thus, supposing the United States to be at war with some country of superior naval power; supposing the United States to possess six torpedo-boats and no more; supposing all those boats to be lying at New York; and supposing New York harbor, with both the Narrows and Long Island Sound, to be closely sealed up by the largest and most efficient fleet that could be collected off the coast:—supposing all this, I say, it would be by no means difficult, if proper arrangements were made, to deal by means of the torpedo-boats a very staggering blow at the blockading fleet, and, moreover, to deal it from the least expected quarter, namely from seaward.

In 1887 experiments were made in France to test the transportability of torpedo-boats by railway. The first-class torpedo-boat No. 71 was sent overland from Toulon to Cherbourg in August of that year. The special train which carried it consisted of three carriages, two freight-cars for the armament, two more freight-cars for the stores and gear, and a series of specially constructed trucks for the boat itself. The boat measures 108 feet long, 10 feet 8 inches broad and 9 feet deep, and at the time of transit weighed 38 tons. It reached Cherbourg in four days, but it did not travel by night; and so it may be assumed that had promptness been necessary it could have covered the distance of about 700 miles in forty-eight hours or

less. The cost of the single experiment was, at the time, stated to be but 7000 dollars. In the total the expense of the specially built trucks was, of course, a very large item.

What could be done in France could be done with even greater facility in the United States or in England. In the case which I have imagined, the boats shut up in New York could, in a very short space of time, be transported say to Atlantic City, Cape May, New London, or Bristol, R. I., whence, having awaited a favorable chance, they might operate with deadly effect, and probably with small risk, upon the rear of the blockading fleet. The only special appliances that would be requisite would be the trucks, and at each end of the distance a short branch line of rails running from the existing track into the sea. The trucks could be built in three days; the branch lines could be laid in as many hours.

Probably no attack would have better prospects of success than one conducted in this way; for it might be made from any one of a hundred different quarters, and it would be obviously impossible for any fleet to watch all the practicable points from which the boats might be launched upon their mission. But the case which I have imagined is an extreme one. Effective blockades are growing every day more and more difficult. In August, 1888, I was with a squadron consisting of the British vessels Warspite, Iris, and Severn, which, without being observed, and with the greatest possible ease, escaped from Bantry Bay, in spite of the attempted blockade of the comparatively narrow-mouthed haven by seven battleships, seven cruisers, and six torpedo-boats. Save in the face of perfectly overwhelming outside force, a well-handled torpedo-flotilla, constituted either as a division or otherwise, should always be able to operate from a port like New York and to strike with the requisite suddenness. It would be from more open ports, or from ports with only one narrow entrance, that effective surprises, without railroad aid, would be really difficult.

And this leads me to the consideration of the three kinds of torpedo-boat attacks which seem to be permissible in the warfare of the future. These are:

A. Attacks from a base against an observing or blockading force that is close at hand.

B. Attacks against fleets or single ships cruising at sea at a distance.

C. Attacks against fleets or single ships at anchor close at hand or at a distance.

Attacks from a base against an observing or blockading force that is close at hand.—This is the form of attack in which the co-operation of the division-boat may, with the least disadvantage, be dispensed with. The approximate position and strength of the enemy are known. The superior horizon of the division-boat is therefore not required, neither is that craft likely to be so urgently needed to serve as a magazine, store-ship and refuge for the division as in the case of operations conducted from a distant base. I do not think that the number of vessels constituting the hostile force should influence the number of torpedo-boats to be employed. French tacticians have suggested that, in the attack, at least three boats should be devoted to each ironclad; but I would not use more than three boats in any attack, whether against a single ironclad or against a whole squadron. A greater number cannot easily be controlled by a single directing intelligence upon the spot; and if I had at my disposal more boats than three, I would utilize them, not in any solitary onslaught, but in a succession of attacks by divisions of two or three boats operating from different quarters at times laid down beforehand by a superior authority on shore. An attack in numbers would inevitably lead to confusion, and probably to collision and damage; for this reason I would not allow even a division of three boats to attack simultaneously *en masse*. The whole secret of success in torpedo warfare must lie in the wide utilization of those moral effects which are produced upon nearly all men by the unexpected, the terrible and the vague; and in order to utilize these to the greatest advantage, my boats, as well as my divisions, should go into action successively. One would be naturally tempted to select for attack the leading or the rearmost ship of the enemy. To choose the center vessels of a column would be to expose the boats to a concentrated fire from several crafts. On the other hand, the leading and rearmost ships, realizing their relatively exposed position, would be apt to be keeping a better lookout and to be more prepared than the others. On the whole, therefore, I am inclined to think that the best procedure is to adopt such tactics by way of commencement as will disorganize the enemy's preconceived ideas, and to then act as prudence and the situation may have suggested.

And here I would say one serious word which applies to all torpedo-attacks. Every contingency must be arranged and provided for beforehand. When the undertaking has once been begun the time for alteration of schemes has passed away. In presence of an

enemy, torpedo-boats cannot signal to one another without danger of betraying themselves, and they must therefore be prepared to do without signaling. But this does not, of course, imply that a single cast-iron plan must be adopted and rigidly adhered to. Alterations may, without difficulty, be prearranged, and their adoption may be made to depend upon the condition of the sea, or of the light, or upon the motions of the foe. If signaling were permissible, the work would be easier; but it should not be forgotten that in the French manœuvres of 1891 Admiral Puech would not, on a certain critical occasion, have discovered the whereabouts of Admiral Dorlodot des Essarts had not the torpedo-boats of the latter's squadron been reduced to making night-signals indicative of their inability to keep the sea. Indeed, the slightest glimmer from a lantern, the striking of a match, or the weakest suspicion of flame above the top of a smokestack may so effectively render abortive all attempts at surprises that nothing of the kind must be permitted upon any pretence whatever.

A fleet engaged in blockading or watching a port may be disposed in any one of a hundred different ways, and is almost certain to be at night in a formation different from that which it maintains by day. But it would nearly always be possible to ascertain something of its habits. There will probably be an inshore squadron of light craft and cruisers, while outside will be the battleships and other heavy vessels. The quarry should of course be the heavy vessels; and the initial problem for the attack is how to avoid the cruisers. The problem solves itself if the idea of transporting the boats by railway to some unsuspected and unwatched base be made use of. If that project be impracticable, the boats must feel their way out as best they can; but those boats which are to immediately co-operate must at all hazards keep together until they have passed the inshore squadron. I mean that if only one division be employed it must not, on any excuse, separate until it is quite certain that the whole of it has got through and is available for the prearranged work. If two or three divisions be employed, each may go out independently; but the second must not start until it knows that the first has escaped, nor must the third go until the second is safe; for just as boats No. 1, No. 2, and No. 3 of each division are dependent, No. 2 upon No. 1, and No. 3 upon No. 2, so are squadrons 1, 2 and 3 of the whole force. It will not be of great importance to Division No. 1 to know that Division No. 2 is out; but it will be of the highest importance to

Division No. 2 to know that Division No. 1 is in a position to do its share towards preparing the way for No. 2's attack.

If the outgoing vessels be fired upon, they should not return the fire, or even hesitate in their attempt, so long as there remains the remotest possibility that they are not clearly seen and recognized. Experience shows that cruisers often fire at things which exist only in the imagination of some excitable man. I well recollect that in 1888, upon the occasion of the escape from Bantry Bay, there was a great deal of firing from the blockading force, and that we all believed that we had been observed. It appeared afterwards, however, that we had not been seen at all, and that the firing had been directed either at an imaginary target or at some of our consorts which, though not trying to escape, were making a diversion in our favor. Nor need the outgoing boats necessarily lose heart if the search-lights of their opponents be flashed right upon them. In 1888 a search-light from the Hotspur was flashed along the whole length of the escaping Severn at a distance of not more than 2 or 3 cables (for we could distinctly see the people around the projector), yet by some chance the Severn was not discovered. But of course, should there be no doubt that the attempt has been fully detected, there should be a retreat. An axiom of torpedo warfare is that, save perhaps where mere picket-boats and launches are her opponents, the torpedo-boat must avoid being attacked and being provoked to fire until she is endeavoring to use her torpedoes. And another axiom is that she must not employ torpedoes as weapons of defense against casual foes, but must reserve them for employment as weapons of offense against the main enemy. Her proper defence is evasion, and if forced to it, flight.

In addition to the position and formation of the enemy, the wind deserves the attentive consideration of the attacking commander. Approach from leeward, especially when the wind is on the beam of the ships to be attacked, seems, upon the whole, to hold out the greatest promise of success; for the smoke of the ships' guns when they open, while sufficient to obscure the boats from the ships, will not be sufficient to obscure the ships from the boats. If there be no wind, an attack is certainly best made from seaward, firstly because that is the quarter which is regarded with least suspicion; and secondly, because the boat, having attacked and discharged her torpedoes, need not lose time and incur risk while turning under fire, but may run straight past the enemy back to port. But special circum-

stances must regulate the interpretation of all general rules. Where the coast is bold, and the depth of water has invited the enemy to cruise close in, it may be found wise to make the attack from under cover of the shadows of the land. In such shadows, both when there is no moon and when the moon is low down over the land, a torpedo-boat can only with the utmost difficulty be detected. It was by taking advantage of the land-shadows that the boats of the Blue Squadron were able to approach the Red Squadron at anchor in Luce Bay on the morning of July 26 during the British manœuvres of 1891. I was watching for them with an excellent night-glass, but, while in the shadow, they were absolutely invisible, although they were less than half a mile away, and although the night was by no means a very dark one. I do not desire to advocate the making of the attack from any particular quarter, so much as to dwell upon the necessity for well organizing it beforehand, and upon the advisability of prefacing the real attack with one or two feints from a different direction.

On the eve of an attack the boats to be employed should test all their torpedoes both as to immersion and as to the working of the machinery. The weapons should then be freshly charged, and, finally, everything should be formally and severely inspected by a responsible and specially qualified executive-officer accompanied by an engineer-assistant. The inspection should take cognizance of officers, men, armament, engines, charts, instruments, etc., down to the smallest detail, and, the general plan of attack having been decided upon, all possible contingencies must be provided for. The main object to be attained is that, at the specified hour for the commencement of the action, all boats shall be in their prearranged position, and that each commander shall know what every other is going to do and when he is going to do it, and also what he himself has to do, and at what moment. All is to tend to the due carrying out of successive single concerted feints and attacks which have been prearranged and set down with the conciseness and accuracy of the entries in a railroad time-bill.

The chief cautions to be observed, so far as experience causes them to occur to me, are, that boats should never expose themselves longer than is absolutely necessary, and should, as quickly as possible, withdraw out of sight and rapidly shift position so as to appear next time from a new quarter. Haste and excitement must be studiously repressed by the officers, who should themselves discharge

the torpedoes from distances never exceeding one cable: in returning to port after action boats must throw off the rule of secrecy and in some unmistakable manner announce their approach to their friends, signaling also whether or not they are pursued. If this precaution be not taken the returning boats will certainly be fired upon. Sir George Tryon's well-known maxim is: "In war-time, if you see a doubtful torpedo-boat, fire at her without waiting to ask questions"; and, in offering this advice, the gallant admiral is fully justified by all that has been seen of torpedo-boat work in the past. I think, however, that if returning boats made use of some very conspicuous rocket-signal, each boat having her own for that particular night only, no risk would be run by not firing at her. On the other hand, if there be the slightest doubt about the craft, she must be attacked as she comes in. Wherever it may be feasible, I should advise that boats do not return to port until daylight, and, in the meantime, take refuge in some unwatched cove or lie to where they are out of danger. It would indeed be a misfortune if boats, after having done good work outside, should come back to be sunk by their friends. But the risk is a very real one. Every recent series of manœuvres in England, France and Germany have exemplified it.

Attacks against fleets or single ships cruising at sea at a distance. In this kind of attack the division-boats may play an exceedingly important part. They can save their division from much useless wear-and-tear and exhaustion at sea, and can enable them to go fresh into action. The torpedo-boats themselves are, as has been said, not fit to attempt to keep the sea. If they do so they do it at the expense of the nerve and physique of their officers and men. But the division-boats can keep the sea without danger of this kind; and it is therefore an unfair test of the capabilities of a torpedo-flotilla to send it, as was done during the British manœuvres of 1891, to worry and attack a seagoing fleet, and to deprive it of the co-operation of torpedo-gun-vessels. It is equivalent to sending a battleship fleet to sea without cruisers.

When one talks of torpedo-attacks against ships at sea at a distance, one speaks, of course, relatively. No one dreams of attacking in this way a fleet in mid-Atlantic, or even five hundred miles from shore. But a fleet operating, for example, in the Adriatic, in the English Channel, in the Irish Sea, among the West India Islands, or within, say, 150 miles of any coast-line, would be susceptible of attack by an enemy possessed of a shore-base within range. That

base need not be one prepared beforehand. Only a safe and unobtrusive haven for torpedo-boats is needed, and any retired little bay with a sufficiency of water and not too difficult an entrance will serve admirably.

From the base, having first seen her smaller consorts snugly anchored in it, the division-boat issues. If there be two division-boats so much the better. They go forth alone, and at 18 or 19 knots speed. They scour the seas in search of the enemy. Having found him, they follow him a little so as to discover, if possible, his intentions, and then send or take back information to the base. If they be near a friendly coast, they telegraph the information from the next point and order a rendezvous. If they cannot telegraph, one of them must go back with the news; but as the division-boat should be able to cover about 150 miles in eight hours, and as a fleet, unless pressed, does not do much more than half the distance in the same period, the loss of time, though regrettable, is not particularly serious. Upon receiving the information the torpedo-boats make the best of their way to the rendezvous. This brings them somewhere in the neighborhood of the fleet. They pick up their division-boat and follow the quarry, taking care, however, to keep well away from his cruisers by daylight. At night an attack, arranged very much as in the case of an attack upon a blockading fleet, is made, the division-boats covering their divisions as much as possible, and then standing by either to attack meddlesome cruisers or to render help to their divisions in case of need. I do not think that they should approach ironclads unnecessarily, for they are comparatively large targets, and big shells bursting in them may easily be fatal; but I think that they may advantageously interfere to harass and take off the attention of the enemy's scouts; and if one of the latter should be a little rash or unwary, there may be an opportunity of torpedoing her. Before any attack, a rendezvous for each division should of course be arranged. If there be more than one division, the two points of rendezvous should be well out of sight, but not too far distant one from the other. Once more a series of successive single concerted feints and attacks, directed according to plans as prearranged, seems to promise the best chance of success. I desire, however, to call attention to some of the relative advantages and disadvantages of attacks from ahead and attacks from astern upon a fleet under steam; since a consideration of these may influence a divisional commander in his choice of the quarter whence he will attack most seriously.

The economical steaming speed for most large ships is about ten knots. This is about the speed at which a squadron would be likely to cruise in war-time, unless it were engaged upon some pressing duty; and it is a speed which is roughly equal to 17 feet a second. The attacking speed of torpedo-boats ought to be at least 18 knots. This is a speed equal to over 30 feet a second. On a moderately dark night a torpedo-boat approaching is not much exposed to detection by the lookouts in a battleship so long as she is at a greater distance than 2000 yards. She may, of course, be prevented by cruisers and light craft from approaching even so near as that. But for the purpose in hand I will assume that she is not. The range at which, with reasonably favorable prospects, she may discharge her torpedoes at night at a moving target does not probably exceed 150 yards. It becomes, therefore, in the highest degree important to her to traverse in as brief a period as possible what I may call the Helpless Zone—the zone, I mean, in which, although she may be discovered and fired at, she cannot effectively attack in return. She will naturally traverse it most quickly if she approach from ahead on the line of the enemy's course.

In the case of vessels having the speed given above, viz. 17 feet per second for the ship, and 30 feet per second for the torpedo-boat, the times occupied by the latter in traversing the Helpless Zone of 1850 yards (5550 feet) are:

If attacking from right astern	7 mins.	7 secs.
If attacking from right ahead	1 min.	58 "
Balance in favor of attack from ahead .	5 mins.	9 secs.

Seeing that, so long as she remains in the Helpless Zone, a torpedo-boat is liable to be struck and damaged or sunk, without being able to do the work upon which she is employed, this possible reduction of the period of exposure deserves serious attention. What it means may be illustrated by a moment's consideration of the enormous number of projectiles which a modern vessel can launch at an opponent in the space of a single minute of time. Many a battleship of recent construction can bring to bear right ahead or right astern two heavy guns, six rapid-firing guns, and six machine-guns or revolving cannon. Leaving the heavy guns aside, the rapid-firing guns could, in a minute, fire eight and the machine-guns 200 projectiles apiece. This, from such a battleship as I have in my

mind, would give a total of 1240 projectiles of all sorts per minute. Surely it cannot be a matter of indifference to the commander of a torpedo-boat whether he run the gauntlet of about 2470 projectiles or of about 8750. Nor is this all. The slower the approach of the boat the greater will be the accuracy of the ship's fire; and the more prolonged the exposure, the more will that accuracy of fire increase. In addition—and this is very important—a torpedo discharged from the boat coming down ahead will near the ship much more rapidly than one discharged from a boat following astern, and will afford proportionately less opportunity to the enemy to outmanœuvre it. But although I would attract attention to this, I do not wish to be understood to imply that any torpedo ought to be discharged from right ahead or right astern. A torpedo discharged from right astern is liable to be deflected by the wash from the ship's propellers, and has, moreover, but a small target; and a torpedo discharged from right ahead has not only a still smaller target, but has also to contend with the ship's bow-wave, which is almost certain to deflect the weapon harmlessly astern. The proper position from which to discharge the torpedo from a boat coming from ahead seems to me to be broad on the ship's bow; and from one coming from astern, broad on the ship's beam. In each I would prefer to use broadside rather than bow-tubes; for bow-tubes, when boats are running at high speed, often act most unsatisfactorily. Many authorities advocate that an effort should be made to hit the enemy in the neighborhood of his propellers and rudder; but experience seems to show that, if you can fairly explode your torpedo anywhere against his side, you will do him all the damage that is necessary; and undoubtedly, if you aim at him amidships, you are less likely to miss him than if you aim at his counter. If you succeed in disabling him in any way, his next astern may complete your work by running him down in the confusion.

I have dwelt somewhat upon this question of the direction of the main attack because, although it is quite obvious that, at least in some respects, the attack from ahead is much less risky than the attack from astern, nearly all the attacks which I have seen made during manœuvres upon ships under way have, strange to say, been executed by boats coming up from astern. This attack will always, I suspect, be the favorite one in peace manœuvres, because for various reasons it is in peace-time the easier to attempt. It may also be the fact that vessels habitually keep a worse lookout astern than ahead.

But I do not think it will be the favorite mode in actual war; for it bids fair to be too costly in men and material, owing to the relatively long exposure in the Helpless Zone. The attack from ahead against ships under way was not attempted at all during the British manœuvres of 1891. Two torpedoes only were aimed at ships under way, and both of these were discharged from boats approaching from astern; and all the threatened attacks came from the same quarter.

How to get safely out of action will be almost as difficult a problem as how to get safely in; but nothing more generally wise can be counseled than for the boat which has already swerved a point or two, in order to bring herself on to the bow or quarter of her opponent, to complete a turn of eight points, if there be a second ship in the line, and to get away as fast as she can, showing her stern to the enemy's broadside, and so affording as small a mark as possible. If, before doing so, she can discharge a second torpedo, so much the better; but when withdrawing she must not lose sight of the probability that she will encounter a cruiser or be pursued by one, and therefore, as soon as she is out of the zone of immediate danger, she should sharply alter course for the quarter which seems to promise her the greatest security. It may appear inhuman to say so, but I cannot convince myself that a torpedo-boat, having sunk her enemy, should stand by to assist the survivors. Her crew is obviously too small to resist an attempt made by numbers and desperation to seize her, and she has no accommodation for prisoners. When there is no second ship, the best course is for the torpedo-boat to maintain her original direction. Using the helm involves delay, no matter how handy the boat may be, and should, when practicable, be avoided. Not far away, the boat should be able to rejoin her division, and with it she should be comparatively safe.

Attacks against fleets or single ships at anchor close at hand or at a distance.—I regard this as the least promising mode of attacking ironclads by means of torpedo-boats, for all modern ironclads have, or may have, torpedo-nets; and vessels properly commanded and possessed of nets would not fail to get them out immediately after anchoring in war-time. It is true that Captain A. K. Wilson, of the British Navy, has invented a species of shears which, fitted to the head of the torpedo, will enable it, provided all goes favorably, to cut through some existing nets; yet it is equally true that the invention, though ingenious, has little practical value, and that nets strong enough to defeat it could be easily carried, even if it were all that it

is intended to be. But certain vessels do not, and are not likely to, carry nets; and these, especially if they can be thoroughly surprised, may be attacked at anchor with good results. It may also be sometimes worth while to descend upon battleships immediately after they have anchored, in reasonable expectation of finding that they have not had time to get their nets out. As a rule, however, battleships will in war-time get their nets out and in very quickly. I know of ships in the Mediterranean which, when first commissioned, could not execute either manœuvre in less than three hours, but which can now do either in ten minutes. Commanders should, therefore, turn their attention to inducing hostile men-of-war at anchor with nets out to take their nets in, and to make them also, if possible, get under way. This they may sometimes do, particularly when the vessels are lying elsewhere than under forts, by obtaining the temporary co-operation of battleships of their own. Ships in unfortified havens will remain doggedly anchored when threatened by torpedo-boats, but not when threatened by craft of their own class, and when in deference to a feint by battleships they weigh, the torpedo-boats may dash in and find their opportunity. When an attack is made, the same considerations should guide it as should guide other attacks. Surprise, efficiency of men, machinery and weapons, and concerted action, are all-important factors in the success of the undertaking; and if the attack can be delivered from the most unexpected quarter —which in this case is the direction of the shore—it will have the best chance of doing well.

It is claimed for some of the most modern "marks" of the Whitehead torpedo that, if they hit a net fairly and squarely when running at full speed, they will penetrate it. This may be so. If they explode in contact with it, they will certainly demolish great part of it, no matter how it may be boomed out, and therefore it may occasionally be worth while to organize a torpedo-attack with a view to first destroying the nets and then the ships; but this seems to me to be a risky and precarious device, and one which should not be attempted where there is a possibility that other methods may, within a reasonable time, become practicable.

So much for those forms of attack which seem to be permissible.

The attacks which, in my humble view, are not permissible are attacks by daylight, and attacks during actions wherein two fleets are engaged. Concerning the almost absolute hopelessness of suc-

cess by daylight against any respectable enemy, I need, I think, say nothing; but it is necessary to say a word concerning attacks during actions wherein two fleets are engaged: firstly, because French tacticians notoriously believe them to be practicable and even advisable, and secondly, because at least one very capable British naval officer may be suspected of holding the same opinion.

The tactical unit of the French fleet consists to-day of a division commanded by a rear-admiral, and consisting of three ironclads, three cruisers, and three torpedo-boats. This unit was adopted a few years ago, and was deliberately readopted for the manœuvres of 1891. And, in his recently published book on "The Development of Navies," Captain A. Eardley Wilmot, of the British service, criticising the battle of Lissa, says:

"One thing is wanting to complete the valuable experience gained on that day and make it applicable to the present time. No locomotive torpedoes were used, this arm as a naval weapon not having been then introduced. Whether, after the line was broken and the ships were all mixed up together, it would not have been as dangerous to friend as to foe may well be questioned; but small vessels, specially armed in this way, would have had good opportunities of gliding in under cover of the smoke, and dealing deadly blows to partially disabled ships."

The objections to the use of torpedo-boats in fleet actions are two-fold. If they be used in fleet actions, they must, of course, accompany fleets to sea; and, whenever they have hitherto done so, the inconvenience of the plan has been abundantly apparent. They cannot, in bad weather, keep up with ten-knot battleships; they are perpetually in distress, and their crews get worn out and incapable of energetic action. Lieutenant Charles C. Rogers, U. S. Navy, in his summary of and comments on the naval manœuvres of 1890 (General Information Series No. 10, Office of Naval Intelligence), says of the French operations: "The battleships and cruisers behaved well at sea, but the torpedo and dispatch-vessels were a source of anxiety. Several times the battleships were obliged to take some of them in tow. The manœuvres seemed to prove that they have not sufficient endurance. Their very powerful and complicated engines are in small and light hulls; and in continued bad weather, which occurred during the later manœuvres, the personnel gave out constantly." And in his report on the French manœuvres of 1891 (*Marine Rundschau*, November, 1891) Kapitän-Lieutenant von Klein,

of the German Navy, remarks of the torpedo-boats: "These, which, with their superiority of speed, were intended to attack the enemy during the night, experienced trouble and discomfort in keeping up with the squadron at 10 knots. Those of A. Squadron, the ships of which steamed at 12 knots, were absolutely unable to preserve station, and had to be sent away to await better weather." This distinguished officer, in summarizing the lessons of the operations, suggests that they indicate that the proper functions of torpedo-boats are not understood in France, and that such craft should be entirely restricted to service as part of the mobile coast-defenses.

The other great objection to the employment of torpedo-boats in fleet actions has been hinted at by Captain Eardley Wilmot, and is, I am sure, a very real one. The boats would be as dangerous to friend as to foe. I have shown how, in 1890, No. 86's torpedo, intended for the Black Prince, apparently hit the Anson; and how No. 59's torpedo, intended for the Northumberland, hit No. 51; and how, in 1891, No. 42's torpedo, aimed at the Hotspur, struck the nets of the Northampton. I have shown, too, how, in both these British manœuvres, quite a number of torpedoes that had missed their mark were wandering about after almost every attack; how the same thing happened at the attack on the Blanco Encalada; and how probable it is that something similar will happen in the case of every future attack. What, then, would happen to two fleets of ironclads mixed up in a mêlée with two flotillas of torpedo-boats? The question seems to me to require no answer.

But there is a mission for small torpedo-boats, accompanying large ships to sea and acting from them as from a mobile base. The British torpedo depot-ship Vulcan—a comparative failure, I admit, yet the representative of a type which may easily be improved—carries six of Yarrow's 60-feet 16-knot boats, and these, dropped into a comparatively smooth sea within a reasonable distance of a hostile squadron, might, in certain circumstances, do very useful work. A land base is, however, always much superior to a floating one. It admits of larger and faster boats being employed; it gives the boats far better shelter; it involves much less wear-and-tear; and, in brief, it is above comparison with the other, which is at best a *pis aller*. A Vulcan, caught in daylight by a couple of fast ironclads, with her flotilla waiting around her to be hoisted inboard, would not be in an enviable position. A good land-base, containing an equal number of torpedo-boats, would be vastly safer, and could be easily rendered

so strong as to be perfectly secure, unless forces were landed to co-operate against it.

The limits prescribed for this paper will not permit me to offer any remarks on the subject of the handling of fleets and large ships in presence of torpedo-boats, but there remain some general considerations to which attention may be advantageously paid.

The French and Italian Governments have adopted the principle of establishing " nests," or small military harbors for torpedo-boats, around their coasts. This seems to be an unwise proceeding. A " nest," the existence of which is perfectly well known, can be guarded against and easily attacked. An impromptu " nest," on the other hand, can be quickly created almost anywhere on a deeply indented coast; may be quite as serviceable as a permanent one; and may, for a considerable period, exist in war-time unknown to the enemy. A permanent "nest," moreover, must be in some way protected by expensive works or by mines, while an impromptu "nest" may be, for a time at least, protected by the secrecy with which it has been formed. Stores and provisions for torpedo-boats can quickly and easily be sent to any point of a civilized country by rail, and it is almost as convenient for the boats to take them on board at one place as at another. Therefore I would strongly advocate impromptu, as opposed to permanent, torpedo-boat stations. The former conduce to mobility; the latter really tend to restrict it; and it is the mobility, within, say, a distance of 200 miles of your coast-line, of your torpedo-flotilla that, more than anything else, measures its utility. With a sufficient, efficient, and completely mobile torpedo-flotilla on its coast-line, a country should be able for a long time to keep any maritime enemy at a very respectful distance. Permanent stations are well enough in peace-time; in war-time, the first step would be to abandon them in favor of impromptu ones.

It has often been debated whether or not the search-light should be employed by torpedo-boats in the attack. My experience indicates that generally it should not. Silence, darkness, secrecy—all these are, as a rule, favorable to the boats, and they cannot be, as a rule, too carefully observed. But when an approaching torpedo-boat, which has been seen and fired at, discovers that the enemy has got her range and is doing her damage, she may, I am convinced, often save herself by boldly flashing her light full in the eyes of the gunners. I saw a case in 1891 in which, after the light had been so used, the range of the boat seemed to be entirely lost. The use of search-

lights, and especially of search-lights as against search-lights, is a subject which has not yet been sufficiently studied. As at present advised, I would prefer to dispense with them on ordinary occasions of defense as well as attack. The glare exercises a prejudicial and varying effect upon the eyesight, at the time as well as subsequently; and, while it may make valuable revelations, it may also make dangerous betrayals.

For the numerous failures of torpedoes to hit their target, and even to run at all, I think the human element is more to blame than the mechanical. Familiarity with the weapons on the part of those who have to use them will, as training improves, reduce these failures to a minimum; and the weapons themselves have now reached so great a degree of perfection that they leave very little to be desired. I do not mean that it is impossible to conceive a better automobile torpedo than the latest mark of Whitehead, but I do mean that the Whitehead seems to have very nearly exhausted such improvements as can be made in it; and that at present, although it has some inherent and inevitable defects, it is, upon the whole, better than any other torpedo. This is, I believe, so generally recognized that I am entitled, in dealing with the torpedo-warfare of the immediate future, to assume, as I have assumed throughout, that "torpedo" and "Whitehead" are almost interchangeable terms. Inventions, based upon principles which do not resemble the principles of Mr. Whitehead, are numerous, and several of them are very full of promise, and will some day, I doubt not, come to the front. But for the next year or two, should any naval war break out, the torpedo to be used will be the Whitehead chiefly, if not exclusively, or, of course, the Woolwich or Schwarzkopf, which is essentially the same thing.

The kind of warfare which torpedoes and torpedo-boats and vessels promise to introduce to us is not perhaps a warfare of the most heroic and chivalrous nature. Torpedo-vessels will not—and as the Aconcagua affair seems to show, cannot—meet other opponents in the open day and vanquish them with powder and shot in the old-fashioned style. It will be their function to steal up in the dark and deal a blow which some may deem rather the blow of the assassin than of the hero. But these considerations must not blind us to the immense value of these little craft when properly employed. War is to-day less than ever to be made with rose water and waged in kid gloves. Chivalry has less and less place in it. Utilitarianism in war, as in almost everything else, overrides

natural predilection. Nor is torpedo warfare an employment in itself unworthy of a patriot; for in it he may exhibit qualities of the very highest character, and only by devotion, steadfastness, carefulness, coolness and bravery, can he hope to gain the slightest success in it. If these few reflections of mine should help any patriot to the efficient defense of his fatherland, or if they should tend to convince any ambitious nation of the growing dangers of aggression, they will not have been set down in vain.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

CELLULOSE AND ITS APPLICATION AS A PROTECTION TO VESSELS.

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The idea of protecting vessels by means of a very light, self-obturating material was conceived by Admiral Pallu de la Barriere, an officer in the French navy. Being a learned man, as well as an officer of great merit, Pallu de la Barriere devoted a large portion of his life to studying the various methods of protecting those marvellous and formidable floating fortresses which constitute the basis of naval power in every great nation.

In some notes written some years ago the Admiral proclaimed the following, which, in his mind, embodied the main points of naval architecture:

"The battleship, in order to be properly qualified for naval warfare, ought not only to be unsinkable, but she should also preserve during the entire action her stability, her manœuvring power, and the height of her gun-platforms."

He then adds that "the unsinkable quality of ships varies in the merchant- and war-ships.

"A steamer belonging to the Messageries Maritimes was able, after a collision on the ocean, to continue her voyage from Japan to China after her prow had been torn away." This he designated "commercial unsinkability."

"An ironclad, struck by the ram of another battleship, was able, during 1½ hours, to float and reach a point where she intentionally stranded, although her two forward compartments were filled with water."

"This could not be called naval unsinkability. The vessel run into had lost her turning power; the form of her lines had been changed; her rudder was useless, and, therefore, in case of war, the ironclad would have been easy prey."

"The whole future of naval and military construction is contained in this one instance.

"When science has given a correct form to the idea of a vessel, that is to say, a buoyant body filled with a light substance which can be accepted as permanent for all space not used, to enable her to live, to progress and to fight, then it will have produced a battleship which will enter the fray with undisturbed firmness and without fear that the engines of destruction directed against her will be able to affect her in any way, besides being endowed with a species of artificial life sufficient to last throughout her role of destruction."

The realization of this problem (we might say of this dream) Pallu de la Barriere discovered in cellulose, the application of which has now entered into general practice.

There is a story connected with the discovery of the properties of cellulose; like nearly all other great discoveries, it was due to chance. A few years ago the crew of a French man-of-war were engaged in target practice not far from New Caledonia, when, to the general wonder, after each shot it was found impossible to locate the spot where the projectile had struck. They were all certain that the target had been hit, but no sooner did the projectile reach it than it seemed to disappear as if by magic. The commander at the time was the late Pallu de la Barriere, who at once started an investigation which led to the discovery that the shore which had been fired at was not an earthern target, as it was covered with the refuse vegetable matter from a factory where rope was made from cocoanut-fiber, where it had been accumulating for several years. The waves dashing on the shore had massed this fiber and dust into a hillock which the severe storms of the rainy season were unable to wash away.

This strange phenomenon attracted the attention of Captain Pallu de la Barriere, and he came to the conclusion that if such a substance could be applied to vessels of war, the ships protected by it could not sink, as their wounds would close of themselves and so prevent the inflow of water. Besides, this kind of protection would be very economical, as one had but to pick up waste material which was only in the way and of no value to the manufacturer; something that

he would gladly offer for nothing to save the cost of removing it himself. He had some tanks constructed which were filled with cellulose taken from that discovered on the beach. He then fired several shots into the cellulose, but the results did not come up to his expectations, as the marvellous effects which were observed when the great mass on the beach was fired at were not reproduced when only a few cubic meters were used.

The experiments were not carried further at this time, but Captain Pallu de la Barriere did not lose his faith in the value of this material, and after extensive experiments carried on by himself, he concluded that the processes employed by the manufacturers of goods from fibers destroyed in a great measure the very qualities which he sought. It was found necessary to sacrifice the fiber almost completely in order to give to the cellulose, by a special process, its maximum effect in small bulk.

I wish to add here that not only the processes, but the application of the cellulose itself to the protection of vessels is covered by letters patent all over the world.

As soon as he had perfected his invention, Captain Pallu de la Barriere laid it before the French Government. His statements were at first received with a general air of incredulity. It was the opinion that he was not in his right mind when he pretended to be able to protect men-of-war by means of this dust so light that a single breath would blow it away, just at a time when experiments had proven that the most formidable ironclads could be penetrated by chrome-steel projectiles.

However, experiments were ordered with the new material. For three years most exhaustive trials were carried on and the results carefully studied. The experiments were kept secret, but the results were so conclusive that the Government issued a decree that cellulose should be used on not only the vessels then under construction, but upon all the old cruisers and battleships.

Since this time, the greater number of the vessels built in France for foreign governments have also been protected by a belt of cellulose. It was in this way that Russia, Holland, Greece, Denmark, Norway, and even Japan have been induced to favor the use of cellulose in their vessels of war.

Hon. B. F. Tracy, the present Secretary of the Navy, wishing to provide the vessels built during his administration with all the improvements which modern science has brought about, desired to

have them protected by a belt of cellulose, there being no doubt as to its practical efficiency after the many successful experiments at Norfolk and elsewhere that are reported.

The manufacture of cellulose has now become a domesticated industry, since, in Philadelphia, a company has been organized which has built a factory which will be of sufficient capacity to supply the entire American Navy. The American cellulose will be in every respect identical with the French article, since the company has not only bought the French patents, but has had all the necessary machinery built there in the workshops of the inventor.

For a number of years past there has been an incessant conflict between the gun and the armor-plate. The thickness of the latter has grown while keeping pace with the ever-increasing penetrative power of the projectile. But this conflict must soon come to an end, as we well know that to go much beyond the thickness of armor now carried by the battleships of the world would be to add so greatly to their weights as to make them unwieldy.

When a projectile passes through the enormous thickness of metal which envelopes the vessel, she sinks the more rapidly the heavier the armor.

Endeavors have been made to localize the inrush of water by a system of cellular compartments, but considering the vast energy of the projectiles used now upon naval vessels, their explosion in the compartments would crush in their sides and cause the rivets to fly off by the hundred, letting vast quantities of water into these compartments which are depended upon to afford buoyancy and stability, —also changing the form of the lines, consequently modifying the action of the screw and rudder and so affecting the speed and manœuvring power.

The constructors recognizing this danger, have made many efforts to fill these compartments with some light material of a fixed weight which would keep out the great quantities of water by filling beforehand the large spaces into which the water might flow. They have tried in succession charcoal, sea-wrack, cork, poplar, and Italian brick or light pumice stone, also bamboo from Cochin China, and even tin boxes. In spite of their apparent great lightness, these substances represented in their totality a very considerable weight. And even if they did keep great quantities of water out of the compartments surrounding the shot-hole, they left the shot-hole itself wide open. It was necessary to try to close the hole under fire of the enemy, and after the leak was stopped to pump out the compartments.

An automatic closing of the shot-hole is the only thing that can efficiently protect a vessel during an engagement.

To attempt to close a hole in the side of an iron vessel while she is under fire is most hazardous, and as there are no efficient shot-plugs, to attempt such a thing would be almost useless. One must see a leak to obtain a proper idea of the violence with which the water rushes in, blinding the men attempting to stem it, dashing furiously aside every obstacle opposed to dam it, and generally demoralizing the crew. The automatic closing overcomes all these difficulties and dangers, since it acts spontaneously and without the aid of man.

It is true that the latest and most improved types of vessels are supplied with most powerful pumps, but at first the inflow of water might be so considerable that the pumps would not be able to handle it, while the forcing out of the water would lead to the expenditure of an enormous quantity of steam which would reduce the speed and interfere most seriously with the fighting efficiency of the vessel.

In other cases, as when small quantities of water enter into certain parts of the vessel, as, for example, above the slopes of the protective deck, while not sufficient to destroy the buoyancy of the vessel, the mobility of this water affects the stability of the vessel, her period and angle of rolling, and so directly the efficiency of the vessel as a gun-platform. This case is well put in a recent article published in the Naval Institute, which says:

"It is apparent that popular opinion regards the case only as one in which a small loss of buoyancy is the worst result, whereas the danger is likely to be critical, not from loss of buoyancy, but from the effect of the small quantity of water on the stability."

Cellulose is not a new substance, as it has been known for years to the botanist and the chemist. It exists in variable proportions in all plants, and in the tissues of certain animals of the lower orders.

The chemical formula representing this substance is $C_{12}H_{10}O_{10}$.

If you will examine a portion of a small branch of a young tree and subject it to successive washings with cold or hot water, alcohol, ether, weak alkaline solutions or diluted acids, so as to remove all soluble substances, you will have left a fibrous or *cellular* material which is in effect the skeleton of the plant,—hence the name of *cellulose*.

The husk of the cocoanut contains a large proportion of cellulose existing in the form of a species of pith which holds together the fibers which surround the nut.

This pith, however, is not chemically pure cellulose, as in its composition there are about 30 per cent of the salts of potassium and sodium (principally chloride of sodium or common salt), traces of manganese, a great deal of tannin and some salts of lead.

The chemical analysis of cellulose made from cocoanut husks is as follows:

Pure cellulose	83 parts.
Organic extracts	10 "
Ashes	7 "
Total	100 parts.

Far from being detrimental, the presence of these salts and the tannin has the great advantage of rendering the substance safe from decay and the attacks of insects.

The sole enemy of cellulose is the oxidation which takes place when iron and water are in contact with it.

All textile matters are in the same manner subject to destruction under similar conditions.

I wish to insist on this point because I wish you to realize the great importance of its bearing upon the practical use of cellulose. It is most essential that the shipbuilders, who must make use of this substance, shall not lose sight of the fact that cellulose, which contains within itself all the necessary elements for self-preservation, might be damaged by neglecting some simple precaution, such as coating the insides of the cofferdams or steel tanks built to hold it with suitable paint which will prevent the condensation or collection of moisture.

Independent of the above qualities, which are chemical in their nature, cellulose possesses physical characteristics which render it invaluable in shipbuilding, for either vessels of war or of the merchant marine.

It is extremely light, being only one-fourth the weight of cork (the substance usually cited when light substances are spoken of).

On account of its cellular structure it is highly compressible, and in consequence very elastic. Again, it possesses in common with other spongy bodies the property of absorbing water very rapidly by capillarity, and to swell up on account of this absorption.

It is well known that any kind of cellulose subjected to the action of nitric acid, or to a mixture of nitric and sulphuric acid, is transformed into a most inflammable and highly explosive substance,

which goes by the name of pyroxyl or gun-cotton, and serves as the base in the manufacture of celluloid. This will explain the confusion which seems to exist very often in the minds of people who are but little familiar with the science of chemistry, between cellulose and celluloid. I have often heard such people express their great amazement that any one should think of lining the sides of ships with such dangerous stuff which might blow them to pieces or cause them to burn like a piece of tinder.

The system of light protection by means of the meal of the cocoanut husk, as conceived by Admiral Pallu de la Barriere, has two distinctly different uses which are often confounded.

First, automatic obturation of shot-holes by a mixture of cellulose and fiber, placed in a loose state in the cofferdams or compartments and then packed. Secondly, to afford an obstruction to the entrance of water into the compartments, by filling them with blocks or briquettes of cellulose.

In the first case the cellulose is employed in the form of a belt of variable thickness, which amounts to 5 or 6 feet in the largest vessels. It exists then in a granulated or pulverized state, mixed with the fiber of the filamentary part of the husk of the cocoanut, in proportions determined by experience as being the best to produce a felt-like mass. The mixture which gives the best results in practice is formed of about 6 per cent of fiber, or more exactly, one part by weight of fiber to fourteen parts of cellulose. This mixture of cellulose and fiber is placed in the cofferdams of the vessels, and there it is compressed to such an extent that it occupies but one-half its original volume.

The effects produced by using this belt, where cellulose and fiber are proportioned according to experience, are, in fact, but the perfection of which wooden plugs furnish the primitive methods. There are in wood two essential parts, one composed of fibrous elements, which adhere to each other and which can produce a sort of felt; the other is composed of round atoms which do *not* adhere to each other and which are cellulose. We have taken from a fruit, whose nature possessed extraordinary qualities of lightness and imputrescibility, two essential parts—the fibrous portion, and a sort of amorphous cellulose—and have mixed them in a proportion to accelerate obturation and to maintain it.

When a projectile goes through a cofferdam filled with compressed cellulose, the elasticity and absorbing qualities of the substance come into play, for the material contains in itself two forces which

manifest and defend themselves while under the influence of the two causes of destruction, the projectile and the water, acting successively at short intervals on the buoyant body.

1. By the force of the projectile, the elasticity of the material (filaments and granules) naturally causes same to give way, making a passage, and then a reaction takes place by which the material assumes its original form, remaining constantly in contact with the projectile until it leaves the cofferdam, and avoiding any kind of a punching effect. The form of each particle of cellulose and its mobility in permitting the granules to slip over each other facilitate this instantaneous obturation, and the disposition of the fibers retains the cellulose in place. The material is not scattered because it gives way, and takes its original place because it is elastic. The density of the penetrated layers is not sensibly disturbed.

2. When the water coming in contact with the material attempts to follow the projectile on its way through the hole, the material develops still another important quality which, up to the present, had been latent. The swelling of each of these particles coming into contact with the water produces a very lively burrowing, the water now being the most active agent to prevent the water itself from passing through. Thus the projectile provokes the obturation and the water makes the wall solid.

Man does not interfere in any way by any supplementary compression, and the obturation may be said to be entirely automatic.

The cofferdam being of limited dimensions, the weight of the water absorbed may be neglected and cannot influence to any degree the speed of the vessel.

If the projectile happens to explode within the limits of the cofferdams, the greater number of the pieces of the shell will be embedded in the mass of cellulose, preventing in this way loss of life and the destruction which the pieces would cause in the structure of the ship. Hence we have here a substance which is not only obturating but ensures also the intactness of the bulkheads enclosing it. While the obturating value of cellulose is not questioned, many people have said that it would be blown out of the cofferdams by the explosion of shells within them. The statements I have made are, however, based upon actual experiments with 6-inch shells.

The other use of cellulose in the form of water-excluding briquettes which completes the system of light protection I shall now speak of. This is intended to answer quite a different purpose. Where it is

used the question of stopping holes need not be considered, but as I have stated before, it is a case of occupying in advance large spaces not utilized in the vessel which would become dangerous when filled with water. It is necessary to fill such empty spaces with a substance which possesses certain essential qualities. It must be very light so as not to add unnecessarily to the weight and so reduce the amount which can be carried in powder, shell, etc. It must be perfectly waterproof, so that it will not absorb water and constantly increase in weight. It must be secure against the various causes of destruction which might in time render it useless, such as insects or rot.

In this case, the qualities of absorption, of obturation, and of elasticity are not aimed at, but it is still to cellulose that we must turn, not in the loose and compressed state, but in the form of briquettes enveloped in a waterproof covering, because of all substances known it is the lightest which can be used for this purpose, and it is not subject to decay or the ravages of insects.

As an example of the comparative lightness of cork and cellulose I wish to cite the following:

The English battleship Inflexible has her cofferdams filled with 143 tons of cork and oakum; viz. 68 tons of cork of a density of 0.24, 75 tons of oakum of a density of 1.00.

If we should fill the same spaces with cellulose of a density of 0.12, the total weight would only be 43 tons, saving 100 tons out of 143 and at the same time securing much better protection.

If, then, we consider that briquettes of cellulose weigh about 8 pounds per cubic foot, while sea-water weighs 64 pounds, we can easily understand the importance of opposing the entrance of water by filling in advance the spaces with a substance eight times lighter than the water which would otherwise fill them.

Coal is often relied upon as a protection against gun-fire, but the extent to which it can be depended upon has led to many discussions among naval constructors, some of whom contend that it is to be depended upon as a protection: on the other hand, if it is to be used in the furnaces of the boilers, we are again confronted by the empty bunker open to the inflow of water.

I do not wish to enter into a discussion as to the merits of coal protection, but it strikes me that even admitting that the bunkers are full up to the moment of going into action and offer in this condition efficient protection, this protection is obtained at a great cost as to

weight, since coal is more than eleven times heavier than briquettes of cellulose.

Cellulose has been proved efficient during a number of years, and it is well established both by experience and practice that the vessel protected by it will continue to float, that is *to live*, even after being struck many times, and that she will preserve during an action her stability, her manœuvring power and the horizontality and height of her gun-platform, that is to say, her metacentric height.

Numerous experiments with different-sized projectiles have been made in France and other countries upon cofferdams filled with cellulose.

The detailed official reports of all these experiments would take up too much space in this article. The reader will be able to find them in a volume shortly to be published about cellulose.

I shall simply take as an example one of the recent experiments made in Norway at the Horten Navy Yard during the month of August, 1890, in order to give you an idea of the effect of shot upon cofferdams.

The target used at Horten was identical in form and dimensions with a cofferdam of the gunboat Viking, then under construction. It represented a belt of cellulose 8 feet high, 7 feet 9 inches long and 3 feet 4 inches thick. Three projectiles of 6 inches in diameter, weighing 68 pounds, were fired into the target. Two of these projectiles exploded within the limits of the cofferdam, and you could see a little smoke in each of the holes where the pieces came out. The shell which exploded in the cellulose ignited a small part of the cellulose directly in contact with the flame. A close examination showed that this fire was only on the surface; in spite of a strong breeze there was no flame, and the parts which were ignited could only be distinguished by small charred spots where the flame had passed.

To arrive at a proper understanding of the damage which might be caused by an accident of this nature, the cellulose was permitted to burn for half an hour; it was then easily extinguished with three buckets of water. The quantity of cellulose burned in each of the holes was scarcely two ounces.

I call your attention to this fact because among the many foolish things said about cellulose by those who do not understand its nature or have an interest in decrying it, it has been said that the presence of cellulose on board ship would lead to grave dangers from fire.

The experiments recently made at Norfolk, Va., by the board appointed for that purpose proved that cellulose, even in a loose state and in the open air, burns very slowly and without flame. And, furthermore, one can easily understand that when it is tightly compressed in an air-tight compartment it would burn even more slowly. Again, as a closing argument and one which is most conclusive, it must not be forgotten that the cellulose is placed in the wake of the water-line of the vessel, hence, when a shot is fired into it, the water which follows the shot at the moment of its entrance would extintinguish the fire if any could possibly occur. Please pardon this digression. I shall now return to the Norway experiments.

One of the projectiles made an irregular hole in the cofferdam measuring 14 inches by 8 inches, the other shots making holes 11 inches by 10 inches.

While it is not absolutely exact to say that cellulose completely stops the inflow of water, you can see that in actual practice the small amount of water which enters may be neglected. When the projectile has passed through the cofferdam and the cellulose is in contact with the water, it gives rise to a sort of filtering action, which increases progressively for about an hour in the same degree as the absorption increases in the vicinity of the part of the projectile. However, the cellulose swells up in proportion to the amount of water absorbed. The cofferdam being of fixed dimensions, as the mass within it swells it follows that the elements which compose it are more closely pressed against one another, so reducing the passages and arresting the inflow of water in the measure that the cellulose becomes soaked. The leaking through always begins with a single drop, and I have seen cases where this drop did not appear for an hour.

In the Horten experiment the shot-holes were immersed in water to a depth of 4 feet, when the following was noticed:

The first drop of water came through the largest hole in about 6 minutes, through the second hole in about 19 minutes, and through the third hole, in the case where the shell had not exploded, in about 38 minutes.

At the end of 30 minutes there flowed through the three holes 2½ gallons per minute, and at the end of an hour 3¼ gallons per minute. In a very little time after, the flow was reduced to 2 gallons per minute for all three holes. It is evident that this small quantity of water could easily be handled by a small hand pump, and that it is insig-

nificant when compared with the torrents which would flow through a hole 14 inches across under a pressure of 4 feet.

As yet no vessel protected by a belt of cellulose has been in actual combat, so that we cannot judge of its action in battle. Recently the Danish government has made a daring experiment which proved its efficiency and at the same time justified the confidence which it had inspired in those who knew it. In May of last year, the last man-of-war built at the Amerger Foelled shipyard at Copenhagen having a belt of cellulose, had a six-inch shot fired through the port bow, the shot coming out on the starboard side. The vessel then steamed about for three hours at a speed of sixteen knots per hour and with the water rising over five feet above the shot-holes. The cellulose proved so effective that at the end of the three hours less than fifty gallons of water were collected in the ship. (See figure.)

At about the same time, during the French manœuvres, the cruiser Surcouf was run into by a torpedo-boat which made a hole 12 inches in diameter in her bow. The boat sank, but the cruiser, thanks to the cellulose, only took aboard an insignificant quantity of water.

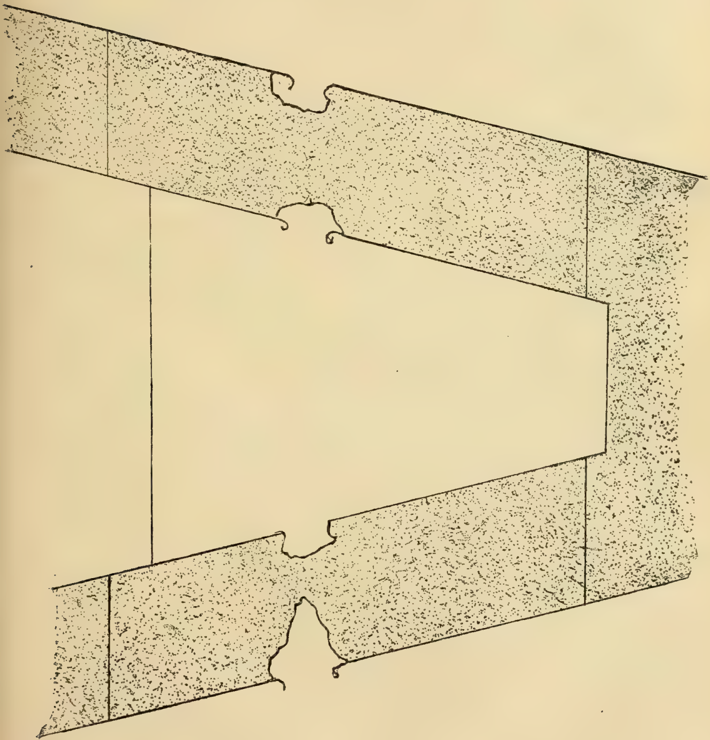
A few weeks later, this same cruiser Surcouf, which formed part of the French squadron when visiting the Scandinavian ports, was run into by the British boat Cormoran during a heavy fog. For the second time upon the same vessel the cellulose filled its role of protector, while the English vessel would have sunk beyond doubt had not the Surcouf gone to the rescue.

I will now refer to the probable use of cellulose upon vessels of the merchant marine. In the near future the passenger steamers will be obliged to follow the path already pointed out in the man-of-war.

It is certain that the system of subdivision into a great number of compartments, which has been in use for several years in the building of large passenger steamers, is the first step towards greater security, but we have actual examples where the enormous vessels have been sunk in spite of their water-tight compartments.

It is evident in certain cases where bulkheads are broken in and adjacent compartments thrown into communication, where the water pours into the vessel, extinguishing the fires, stopping the engines and causing terror and madness in the bravest, the water-tight compartment system is not all-sufficient to ensure buoyancy, because the water-tight bulkheads no longer keep out the waves.

COUPE HORIZONTALE À TRAVERS LA CELLULOSE APRÈS LE TIR.



If by means of a belt or wall of cellulose a protection can be found against the devastating effects of an explosive projectile passing entirely through the belt, how much stronger may be our faith that this protection will be efficient when in place of such an engine of destruction we have only to withstand the shock of wreckage or rocks, which smash, crush or break, but do not pass entirely through.

There may be laws requiring vessels to provide themselves with night-signals, fog-horns and the most powerful steering arrangements, to reduce their speed and to follow the rules of the road in fog and storm. Whether it conform or not to these rules, the steamer provided with cellulose, in virtue of its consequent unsinkability, will have nothing to fear from the blows that she may receive from reefs forgotten by the chart-makers, from icebergs, or even from a blow from another vessel.

In these times of feverish competition, where ship-owners bend every effort to swell their passenger lists, some calling attention to the excellence of their cuisine, others to the comfort of the vessel or the shortness of the passage, the palm must be given to those who can say: "Upon our vessels, guaranteed against sinking and shipwreck, YOU CANNOT DROWN."

A great nation like the American should take the first step in this much needed development of safety at sea, and I should not be astonished to hear at any moment that one of the great ship-yards of Pennsylvania intended to build a fleet of vessels of this nature, to bring to these shores the hundreds of thousands of visitors who will come to the World's Fair at Chicago in 1893.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

OFFICIAL REPORT ON THE BEHAVIOR OF THE U. S. S. BALTIMORE.

By Captain W. S. Schley, U. S. Navy, Commanding U. S. S. Baltimore.

U. S. S. Baltimore, 1st Rate,
Navy Yard, Mare Island, Cal., *January* 6, 1892.

Sir:—After an experience extending over two years and a half in this vessel, during which time she has served in all climates and in all weathers, over an area of the globe embracing more than one hundred degrees of latitude and longitude, it is deemed proper that a report should be submitted to the Department, setting forth that her behavior under all circumstances has been most satisfactory, and that her adaptation to the service has been fully established. It is only just to her builders to state that the workmanship upon her has been found to be excellent, and does them, and through them the country, much honor.

Her stability as a gun-platform, at sea under all circumstances of weather, is superior to that of any ship I have ever served in. Her speed, comfort, and performances under every condition of wind and weather are unexcelled; and, in her class, I question if her superior as a fighting machine exists in the navies of the world. In some respects her fittings might be improved in the new vessels now building, and in this view the remarks which follow are suggested, with the hope that they may not be without their value to the Department. Her defects, where any exist, are merely details, and in this view I will treat them under their various headings, suggesting in all cases a remedy.

COALING FACILITIES.

In my communication of November 29, 1890, from Naples, Italy, I reported the actual time needed to take coal from the lighters into

the bunkers on the occasion when it was required. Subsequent experiences at various other times when the ship has been coaled have sustained the conclusions then reached, and have in no particular varied the results already reported. With more experience, however, in the open roadsteads of Gibraltar, Cape de Verde Islands, Valparaiso, Iquique, and Callao, it has been found that grave objections arise to taking coal from lighters through side-ports into bunkers, on account of the constant swell in these places. It has been found that the rolling swell in all these ports sends the heavy lighters so violently against the ship's side that the stages are unshipped, ash-chutes are smashed, and much time is lost in waiting and watching for smooth times when working, to pass coal safely or surely from lighters to men on the stages, and so into the side-ports to the bunkers.

In most modern ships of other navies that we have met, this plan of coaling appears to have been abandoned for the better and quicker one of taking in over all, and then passing it through chutes extending through the spar-deck to the berth or gun-decks, as much cleaner, more rapid, and most convenient. Under the present plan on board this ship, there is little comfort for officer or man during coaling, on account of the blinding dust which covers the ship inside and out, penetrating every corner and place.

These discomforts might be endurable if limited to a day or two, but when extended over a week, it suggests an annoyance almost intolerable. In marked contrast I would state, that when this ship was in Gibraltar in February of 1891, one whole day was needed to take on board about one hundred and fifty tons of coal. In the same interval of time the great British ironclads Howe and Camperdown took into their bunkers over all about seven hundred tons. While this ship was covered outside and inside with coal-dust, in these ships mentioned it was confined to the spar-decks. The merits of the two systems in cleanliness and efficiency would seem to require no comment.

OUTSIDE ASH-CHUTES.

The chutes on this ship's side, extending from a point near the top of her rail to the water-line, to dump ashes or other refuse, cause much annoyance and discomfort at sea when steaming in moderate winds on the beam or bows, from the seas catching in the angles at the ship's side formed by these chutes, from which it is thrown on board over the rails into the gangways, gun-sponsons, and on to the

guns, so that the decks are constantly wet, forcing men and officers to seek cover under the poop or forecastle-decks, crowded together in a small space. Passing fore and aft at such times results in thoroughly drenching all who attempt it. The same may be said of all projections on the ship's side, such as lips to all the scuppers or drains, though less marked, but which add material resistance to the ship's speed at such times.

The remedy for these evils appears simple if the number of chutes is reduced to two on each side, built on the inside and delivering at the water-line as in all the modern merchant steamers, with a system of overhead trolley railways converging to the two chutes to dump ashes from the fire-rooms below. All scuppers or drains now built on the inside of ships should deliver at the water-line in round orifices to reduce friction resistance and to prevent lodgment of the water that now comes on board in showers, even when steaming in moderate or light winds.

If these chutes were removed from this ship it would be easy to rig a wooden chute sufficiently long to project well clear of the ship's side, to be shipped when needed and removed when not in use.

ANCHOR AND BOAT DAVITS.

In order to obtain a fire directly ahead for the bow guns in these cut-away fine-lined ships, our experience has shown that only one anchor-davit would be needed in place of the two now on board, if placed in the midship line, fitted to swing over either bow, with drift enough to land the anchors on the anchor port. If sheet-anchors are carried, a second davit, of similar design, placed amidships abreast of them, with range sufficient to handle and stow these anchors, would result in saving both weight and expense, and, at the same time, would increase the ease and efficiency in all work with the anchors.

The system of straight, upright, unwieldy boat-davits pivoting transversely on the outside of the ship to land boats in cradles on the gallows-frames has not worked well or efficiently in this ship, for want of some modern appliance to rig them in or out with the heavy boats hanging on them. Being obliged to use ordinary old-fashioned tackles for this purpose, it often happens when there is the least motion that these davits start in or out with much violence and with occasional damage to boats as well as davits. The danger to life is constant whenever they are worked as they must be in this way.

The remedy for this appears simple if a sufficiently strong davit or derrick is substituted to ship through the top of the hammock netting, to step in a heavy saucer securely bolted in the spar-deck waterways, and so rigged as to pivot in a circle about itself with a curve similar at the top to the ordinary side davits of quarter-boats. Boats hoisted to such davits or derricks are easily swung into cradles on trolleys, or out over the side when lifted from them. Such derricks would then be available in coaling over all in these mastless ships, when it is sometimes difficult to improvise suitable means for such purposes.

ANCHORS.

The anchors supplied to this ship are of the Dunn type of cast steel. During the cruise there has been afforded the fullest opportunity under all circumstances of wind, weather, tide, and bottom to fully test their usefulness. It has seldom been necessary to let go a second anchor, and in no instance during the cruise has the ship ever dragged, no matter what the strength of the wind and tide may have been. An anchor, therefore, which never fouls and never drags under any circumstance in service must be superior to all others.

Lying in the Delaware, September, 1889, in a heavy gale with 60 fathoms of chain and a strong tide, the ship was perfectly secure and safe. Again, in the outer harbor at Copenhagen in October, 1890, lying in about 6 fathoms with 60 fathoms of chain and one anchor during a heavy westerly gale, the ship was perfectly secure and did not drag or foul her anchor. Again, in Lisbon, anchored in 20 fathoms of water with 60 fathoms of chain and a single anchor with a strength of tide during springs amounting to five knots an hour, this ship lay for ten days, during which there were strong northerly and easterly gales. There was no dragging, and on weighing, the anchor was clear. In Montevideo, in March, 1891, in a heavy gale, the ship lay securely and safely with one anchor and 60 fathoms of chain, and when hove up was not foul. At Valparaiso, lying in 36 fathoms of water with one anchor and 105 fathoms of chain, the ship rode out several northers of considerable severity accompanied by heavy seas.

Remaining therefore in port with a single anchor down and a moderately fair scope of chain out for weeks under all circumstances, this ship has never dragged nor has the anchor ever been found to be foul when hove up. I can say, therefore, without hesitation that the Dunn anchor supplied to this ship is the most reliable and safest anchor that I have ever known in the navy.

MILITARY TOPS.

It has been found in this vessel that the guns in her military tops, placed above the tops of her smoke-funnels, are of little use with the wind ahead or astern on account of the volume of smoke and intense heat which envelopes them. Owing to this inconvenience, we have always exercised at target practice with the wind abeam to avoid this difficulty. During action with forced draught and a head or stern wind, either one of the two tops would not be habitable for the smoke and heat, so it is believed that the more favorable position for them would be at some point on the military masts below the tops of the funnels, clear of the smoke and high enough above the deck to secure both depression and range of fire sufficient to be fought under all circumstances against the open decks of ships or to be used effectively in the event of attacks by torpedo-boats. The great advantage of rapid-fire guns in these elevated positions seems too important in modern actions to be left to the hazard mentioned, when by a slight change their value and efficiency would be so largely increased.

VOICE-TUBES.

These most necessary means to communicate from the bridge of this vessel with the engine-rooms or with men in compartments below, have been found quite often to transmit sounds or commands unreliably and indistinctly. With the wind ahead or on the beam, the noise made by its whistling through the rigging, or by the swash of the sea alongside, at times makes it extremely difficult to hear distinctly or with certainty, or to transmit with clearness orders below, owing to the small diameter of these tubes and their small mouthpieces, as well as the large number of turns they make at right angles below to avoid obstructions met in the route they follow. Experience has shown that all such tubes for transmitting distinct words should be at least two (2) inches in diameter, terminating in large open mouthpieces, and when necessary to deflect their direction below, all turns should be the arcs of circles. Signal-bells, used to attract attention on deck or below, should be gongs at least six inches in diameter, set to a note easily distinguishable from all other sounds, and of such strength as not to be absorbed by the noise of the wind or sea. I am convinced that the distant service telephone with their improved transmitters would be more reliable and certain in communicating on shipboard. During gun practice the small voice-tubes are almost useless owing to the inrush or the exhausting

of the air incident to heavy concussion. At the beginning of the new departure in construction, voice-tubes were the best means suggested. I believe the telephone an improved system of communication.

ELECTRIC LIGHTING.

The electric plant of the vessel has, in the main, worked rather well. The chief difficulties appear to have been found in the steam separators and drain-pipes leading from them into the feed water-tank. It occasionally happens when changing steam from one boiler to another that quantities of water from pockets in the long steam-pipes leading into the dynamo-engines rush over into the cylinders of these small high velocity engines, with danger and damage to them on account of the drain-pipes being rather too small to relieve the trap in time to save the machines. Constant and incessant watch is necessary to prevent these accidents, even though the drain pipes are now larger than originally designed. The system of lighting and wiring of the ship is most admirable, though the efficiency of the system would be greatly enhanced in value, if in addition, storage batteries could be added so as to insure the maintenance of light for at least twelve hours, in the event of accidents to the machines from the causes mentioned.

Early in the cruise the fact was developed that the brush and commutator surfaces were insufficient for the work imposed. The result was much sparking and consequent wear on the surfaces of both. The new commutators of larger areas with more brush surface have improved this feature to a marked extent, but at times and from causes that seem almost beyond explanation sparking in a modified degree is still observed, though not to any injurious extent. As the surfaces of both improve, increased efficiency and satisfaction have resulted. All repairs have been effected by the force on board, and it is a pleasure to state that this important addition to our need and comfort is much more efficient to-day than at the beginning of the cruise. The search lights are much improved in excellence and brilliancy. It is recommended that they be used with about 45 volts at the lamp, and this uniform voltage is supposed to be maintained by the dead resistance boxes in the circuit. These boxes, however, do not fulfil their purpose, it being ascertained to be immaterial whether the whole or half of the resistance is thrown in, as indicated by the voltmeter outside them in the circuit. Practically, in working one light we have found it better to run direct from the switch-board

with about 45 volts, but with two lights in circuit it is found more difficult, so that the boxes are then used. This defect in the boxes is not to be regarded as an adverse criticism upon the lamps themselves, the power of which depends in a large measure upon the focusing arc and the form and position of the crater at the carbons, where most practice is required to properly manipulate the light. Lieutenant Sturdy has been able with the force on board to make all needed repairs or changes required to secure more efficiency in the excellent machines supplied to the vessel.

BATTERY.

This important feature of the ship is admirably arranged and is carried with the greatest ease and safety. The carriages have worked most admirably, leaving nothing to be desired or suggested. I am sure, however, that her energy of fire and formidability could be enhanced by increasing the number of her secondary battery to twenty guns instead of fourteen that she now carries. There is ample room on the rails, forecastle, and poop-decks for their accommodation, and abundance of room below in her Hotchkiss lockers to stow the necessary ammunition. The destructive effect of a concentrated fire from machine and rapid-fire guns on board modern ships in the future is deemed to be so important as a factor of success in action that it is believed of sufficient importance to recommend a large increase in their number on board this ship. In most of the foreign ships we have fallen in with during the cruise this feature has been observed most prominently as a later improvement. In the matter of supplying the battery during action we are at some disadvantage in handling the ammunition for our eight-inch bow and stern guns by hand in exposed positions. These means are too slow, although in some respects hardly avoidable with the after-guns, as the scuttles from the magazines are not continued on to the spar-deck, but end on the berth-deck amidships several feet distant from the scuttles extending to the poop-deck to supply the after-guns. But with quick-firing guns this disadvantage is so serious as to suggest a change by which the ammunition could be delivered from the magazines directly to the guns, as is done with the forward pair. The celerity of delivery, now so important, might also be improved by the aid of a small electric motor placed in or near the magazine passages operating the lifts.

With the supply to the broadside guns there is no delay or diffi-

culty, for the reason that the ammunition being much lighter is much more easily handled and more rapidly passed to the delivery chutes near each of these guns. As the quantity of ammunition delivered to these guns in a certain time is much more than could be fired away in the same interval, there would seem to be no need for any change in the manner and system of supplying them.

ENGINES AND BOILERS.

These splendid machines have worked throughout the cruise almost faultlessly. The material, work and finish upon them show a high order of capacity and integrity. Wherever defects have occurred it has been rather in the original design, though in this respect, if we except pumps, main condensers and the system of drainage, there has developed but little to occasion complaint. Most of the steam pumps are of English design and of the yoke pattern and are vertical; they get out of order easily and are difficult to overhaul on account of having to be taken down before they can be taken apart. Pumps of American design ordinarily used on board our steamers are without doubt to be preferred. All the pumps for clearing her water-tight compartments of water are located low down in the engine-room compartments, so that if either of these should be flooded the whole drainage system forward or aft would be rendered useless. There have been quite a number and variety of accidents under this condition to demonstrate the importance of locating these pumps outside the compartment system of the ship, so that their usefulness be not imperiled by injuries that would involve their use at critical moments.

Referring to the main condensers, it occurs to me to be inadvisable that the air-pump should be attached to and driven by the low-pressure piston. The slightest injury to the connecting piston-rod would disable one engine entirely, but an inconvenience almost as serious is imposed, in being obliged under the circumstances to start the main engines, often at inconvenient times, to obtain a vacuum, and, in order to maintain it, to constantly keep turning the main engines over every few minutes. Separate air-pumps worked independently of the main engines would be an undoubtedly desirable advantage, wherein some danger would be avoided and much inconvenience overcome.

Condensers of cylindrical shape would be a marked improvement in this vessel, on account of the less room they would take, and the more room they would afford to move and work about the engines.

The system of drainage in its extent and general application is good, although it is made to depend upon pumps that are located in compartments liable to be filled with water themselves, instead of outside of the systems that it is intended they should clear. We have experienced some inconvenience when it has been necessary during a cruise to refit the piston-shoes of both engines. These shoes being filled on their friction surface with white metal squares, to save the bottoms and lower quarters of the cylinders from undue wear, were found worn down to such an extent that it has been necessary to refit and refill one or more of them. As this operation is one in which great care and some time are necessary, the ship was practically disabled during the period required to complete them. If each of the new cruisers were supplied with one spare set fitted for one engine, it would be a simple matter to replace an injured set in a short time while renewing on board ship the metal in the worn set; or, perhaps, if these shoes were made of cast iron softer than that of the cylinder, I am of the opinion they would answer quite as well.

We have met with much inconvenience in using water from the forward feed-tank, which is the receptacle for all condensed steam from the dynamos, heaters, steering, anchor, and auxiliary engines. The oil used in the cylinders of these machines is carried over in the drain-pipes to the feed-tank and from there fed into the boilers, where it deposits in a thick gummy scale that must in time work injury to the main boilers. This tank could be improved by a filter, or by some means to drain off the oil from the top, so as to prevent so much of it being carried over into the boilers in the feed-water.

The two auxiliary boilers of this vessel are too small to run the dynamos, make fresh water, heat the ship, and to use in cooking. The consequence has been that we have been obliged during the entire cruise to keep steam on one of the main boilers for these purposes, and to devote the auxiliary boilers solely to making fresh water for drinking and cooking. It will require for the purposes mentioned above, when not under way, a boiler of at least 200 to 250 H. P. in a vessel of this size, in addition to supplying the main boilers with fresh water for their use, and none other ought ever to be used in them; perhaps an evaporator might readily take the place occupied by one or both of the auxiliaries.

I would suggest that the ash-hoisting engines now placed in small cuddy-holes on the berth-deck, where it is excessively hot when under steam, and where there is not room enough to keep them in proper

order, be transferred to the uptake or drum rooms, where there is abundant room, more protection, and more light in making needed repairs.

It is especially important that all openings under the engine and fire rooms into the double bottoms, except those well up on the ship's sides, should be raised so that the manhole cover will be at least three inches above the bottom of the limber-holes, in order that when necessary to go into these compartments, the water in the bilges may not be admitted, as now happens.

The issuing and tool room of the Engineer Department, whenever it is possible, ought to be located between the forward engine-room and after fire-room, both on account of convenience and for saving time in getting stores and tools when work is going on. Much valuable time that is now taken in getting these things could then be devoted to work.

OFFICERS' QUARTERS.

In olden times, when sail was the motive-power of ships, there were excellent reasons for placing the officers' quarters of ships in their after-parts, in order that the captain might always have the helmsman and the sails under observation, and the watch-officers close to their stations of duty; but in this age of rapidly moving steam cruisers of great length, the deck-officer as well as the helmsman are transferred to stations of duty forward, that greater security may result by this change of position. It would seem then that the same logic that fixed their quarters in the first instance ought to do so in the last, that the officers might live nearer where they are required to be on duty when under way. It often happens that the interval of time between the discovery of danger and the quick decision to avoid it is so short that there is not time enough to allow the captain to traverse the whole length of these long ships, from quarters in the stern to the bridge in the bows, before deciding what should be done. It is possible that instances may occur in which this action delayed from such cause may prove too late. As the seat of control has now gone to the forward end of the ship, the quarters of the officers should follow, to increase the efficiency of command, and to avoid accidents that are possible under present circumstances. As efficiency is the first consideration, it ought to prevail against prejudices which live longer and stronger with us than all else. This change would really be no more radical than that in which the mastless ships of to-day have superseded the full-powered sailing frigates of other days.

MEN'S QUARTERS.

There has been a growing tendency in late years that finds fuller expansion in the later cruisers, to increase the accommodation of officers by encroachment on those of the men. In this respect the Baltimore is a good type to use in illustrating this position, for in her the officers' quarters, with the ship's offices, pantries, etc., take up quite half of the capacity of the berth-deck of the ship. Commencing first with the space devoted to the Admiral and Captain, it could be reduced quite one-half and then be commodiously large. But if both were placed under the poop, as might easily be done, then the wardroom, junior officers' quarters, pantries, etc., could be fleeted aft at least thirty feet or more to afford a larger berthing space for the three hundred and thirty-five men. With the improved systems of ventilation of the new ships there is hardly any suffering, and no injury to health as formerly, but there yet remains much unnecessary crowding together that could be remedied in this ship, and I think in all others, if the officers' quarters were reduced in some such proportion as those of the men.

ORGANIZATION.

With most of the conditions changed by the disallowance of many of the rates usual in ships of war of the older type, it was evident in assuming command that a change of organization was not only forced by this fact, but by many circumstances incident to a type of ship that bore scarcely any resemblance to the older beyond the general external likeness. With so much complicated apparatus that had to be attended to in the new ship, substituted for the many old things that might have been neglected in the older, it was evident at a glance that a change was at hand that had to be met. A little reflection soon fixed the fact that in the modern ships as fighting machines most of the impediments of the older vessels had been removed to make way for battery and engine efficiency, which suggested them as the units upon which the newer organization ought to be constructed. With this end in view, it was decided to establish this organization first, and from it to derive all others in order to secure the desirable object of placing men who are at the same gun-division in the same infantry company, in the same boat, in the same mess, in the same stations, and to associate them in the same work of cleaning, where they were under the control of gun-captains rather than captains of the several parts of the ship. If there is value

in the fact that *camaraderie* in the fellowship of arms is induced by association in the same duties, or in the same exposures, such an organization tends to bring this out fully. The excellent condition of the ship and her appurtenances during the cruise will stand as an evidence of the fact that this organization has had good results.

In these large ships where the duties of the Executive Officer have been made most difficult by the enormous complication and subdivision into water-tight compartments, there are hardly hours enough in a day to attend to the duties required under the new conditions. To relieve this to some extent, the scope of duty of the divisional officer has been enlarged so as to include the care and responsibility, not only of their guns and crews, but also of the cleanliness and good order of the decks, paint work and fixtures within the area included by their divisions. All officers in charge of departments below decks are held responsible for duties in and about them and are required to attend personally or through subordinates to many things that formerly consumed much of the Executive Officer's attention.

In the organization of the battery of this vessel the marines have been assigned to the secondary battery to utilize a force whose rifles in action would be useless, but they have no part in the organization of the crew for cleaning or coaling, in consequence of prohibitive orders and circulars. To some extent they are a privileged class who make dirt, but are not cleaners, as every man on board ship ought to be. It is to this distinction that some of the adverse criticism of their need is due. There is nothing in the character of their duties on board that ought properly to excuse them from the fullest participation with the men in all the ship duties that tend to develop the fullest efficiency of the vessel as a fighting machine.

ENLISTMENTS.

The experience of this cruise in a vessel fitted with military masts, wherewith some of the grades of petty officer are unnecessary, suggests the idea that it might be better to combine all distinctive rates into three classes on enlistment. For example, instead of enlisting men in the rates of master-at-arms, boatswain's mates, machinists, carpenter's mates, gunner's mates, etc., after three consecutive enlistments as at present, it would appear more logical to separate the existing grades of petty officers into three distinct classes, to be known as 1st, 2d, or 3d class petty-officer, and to be enlisted in these grades at a rate of pay nearly equal to that now received under such

divisions in the pay table. Then when these petty officers of the several classes are transferred from receiving-ships to a cruising vessel, it would be within the power of the commanding officer to rate them captains of tops, coxswains, quartermasters, machinists, etc., which properly are rates incident to their service afloat rather than rates in which men ought to be enlisted on re-entering. It can occur in the short period of twelve years that all the most valuable men of the navy will be found re-enlisted in the superior grades of master-at-arms, yeomen, machinist, etc., to which the largest rate of pay is attached.

Under the system suggested, it is believed that much greater efficiency will result to the service in the establishment of a plan which will separate the grade in which a man is to enlist, from the actual rate in which he is to serve after assignment afloat.

If the estimates of men by all commanding officers could be the same in fixing fitness for rates, the present system might answer, but as in this matter the widest divergence of opinion exists, it does not appear just that the judgment of any one officer in fixing the status of a petty officer in a certain grade should be the inflexible rule to govern all others.

When, however, men have been re-enlisted in the grades of petty officer here suggested, they should be entitled to mess in a separate place with a cook attached to their mess, away from the men they are expected to command, and on each re-enlistment under continuous service there might be an increase in the gratuity pay somewhat greater than that in the grades of seaman, ordinary seaman, etc.; and to fix the attachment of these and all other men to the service, I would suggest that leave of absence be accorded to all honorably discharged men after each cruise, as is the case of officers who desire it.

This idea seems to me to be one that would fix in the men's minds and thoughts that they really belong to the navy as a part of its organization in much the same sense as the officer.

RANGE-FINDER.

During the cruise in all target practice, this instrument has been found of the greatest value in accurately determining the distance. On the last occasion of practice in Coquimbo Bay, when the apparatus was not used on account of the battery of dry cells being out of order, a marked difference was observed in the practice where gun-

captains depended upon their own judgment to determine distance rather than upon the range-finder. The less accurate practice of this occasion clearly demonstrated the value of the apparatus used in connection with the modern high-power artillery.

From my observations with the instrument on board this vessel I am convinced that it is an indispensable part of the ordnance outfit of all our new ships. Four instruments, two on each side, so protected by projecting sponsons as to afford a range of nearly 180° would improve the present plan. The forward and after pair to be connected so as to determine the range of vessels directly ahead or astern. The experience of this ship with the instrument shows further that the ships, in contests of the future, supplied with the Fiske Range-finder would possess an enormous advantage over those in which the distance had to be determined in the old way by gun-captains whose judgment would be affected by the excitements and tumult of battle. Indeed, I think I do not overstate its value when I express the opinion that in the naval conflicts hereafter, where ships are equal or nearly so, combats will be decided in all probability in favor of the ships with range-finders, or in case both contestants possess these instruments, actions can last but a few minutes at most, and during this short interval the destruction would be terrific.

COLOR FOR SHIPS.

During the cruise it has not been our experience that white is the best color to paint ships, either for neatness or for service. It is extremely difficult to keep the modern ships in order when painted this color, where it is necessary to coal every fortnight when making a passage, or when lying in the damp and sticky ports of the tropics. It is the most conspicuous of all colors at night and therefore not at all adapted for service in war. It is much more expensive because it is necessary to paint so frequently to maintain a respectable appearance.

At the first signal of war it would be necessary to adopt some neutral tint akin to that which the French have chosen for their coast-guard ships. This shade is the lead color with a slight tinge of green similar to that atmospheric tint observed near the horizon during the morning and evening. Ships painted this color blend most harmoniously with the sky coloring and are almost indistinguishable after darkness intervenes. Of all colors this one appears best adapted to war uses, and as all modern ships are intended to be

ready at all times for war, I would recommend this color for all ships, boats, funnels and spars, so that there should be no necessity to repaint ships in the event of war to complete their readiness for it.

The great precision of modern arms against well-outlined targets makes their color a matter of the greatest importance. The shade I suggest is the best I have yet seen for war vessels.

During the struggle just ended in Chili, the torpedo-boats Almirante Lynch and Condell were painted this color, and on two occasions, one at Iquique and the other at Coquimbo, both these vessels entered these ports at night and were scarcely visible only a few hundred feet away.

PERFORMANCES OF THE BALTIMORE'S ENGINES AND BOILERS.

The adjoining tabulated data (see table next page) represents the performance of the ship under circumstances of service, with the state of the bottom in good, fair, and bad order. It will be observed that the per cent of slip varies considerably with the bottom in foul or in clean condition, while the increase in the coal consumption as shown in the last line is immensely increased without any gain in speed.

The economical speed of this ship is shown to be about 10.26 knots with a coal consumption of about 158 tons to the thousand knots, or about 40 tons per day or about 3600 pounds per hour. At this rate of speed each cylinder of the engine does the fullest economical work at the least loss of speed by the slip.

Though the data here supplied furnish a curious and instructive study of results in actual service, in all cases there appears a larger consumption of coal per horse-power than originally calculated. This reduces her steaming radius largely, and is all the more important in demonstrating the fallacies upon which these calculations have heretofore been based. This table is submitted as an instructive study of her performances.

Very respectfully,

(Signed) W. S. SCHLEY, *Captain, Commanding.*

THE HONORABLE SECRETARY OF THE NAVY,
NAVY DEPARTMENT, WASHINGTON, D. C.

Date.	Revs.	Speed.	Slip per cent.	Coal used per hour.	Coal, tons per day.	H. P.	No. Hours.	Tons 1000 kts.	Days 1000 kts.
July 18, '91	30	4.7	26.7	1683	18.00	203	12.0	159.8	8 days 21 hours
May 25, '90	40.2	7.1	16.4	2140	22.9	524	5.0	134	5 days 21 hours
July 16, 17, '91	45.0	7.58	20.0	2525	27.05	715	17	149	5 days 12 hours
August 25, '90	50	9.3	12.2	3713	39.78	806	24	178.5	4 days 12 hours
August 24, '90	50.9	9.1	15.2	3300	35.35	860	8	161.8	4 days 14 hours
May 15, '91	50	9.0	15.0	4189	44.88	757	19	207.6	4 days 15 hours
July 16, '91	50	8.5	19.8	3215	34.44	992	6	166.9	4 days 21 hours
May 17, '90	54.7	10.0	13.0	3705	39.7	919	24	165.4	4 days 4 hours
May 19, '90	55.7	10.26	13.0	3657	39.18	971	24	158	4 days 1 hour
July 23, '91	55	9.1	22.0	3600	38.57	1240	3	177	4 days 14 hours
November 13, '90	60	11.2	12.0	4268	45.73	1301	6.7	169	3 days 17 hours
December 11, '90	60	11.0	13.6	4100	43.93	1238	2	177	3 days 19 hours
April 2, '91	60	11.66	8.4	4705	50.41	1284	24	180	3 days 14 hours
March 8, 9, 10, 11, '91	60	11.4	10.5	4220	45.00	1204	96.9	165	3 days 15 hours
May 19, '90	60.5	11.5	10.4	4200	45.00	1194	3	163	3 days 16 hours
June 16, '90	65.2	12	13.2	5468	58.6	1495	5	205	3 days 12 hours
April 27, '90	80.6	15.1	11.7	6100	65.3	2825	4	170	2 days 18 hours
August 21, '91	84.1	13.6	23	10194	109.2	4158	6	337	3 days 2 hours

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ELECTRIC WELDED PROJECTILES.

MANUFACTURED BY THE AMERICAN PROJECTILE COMPANY, UNDER THE PATENTS OF PROF. ELIHU THOMSON AND WILLIAM MAXWELL WOOD, U. S. N.

BY HIRAM PERCY MAXIM.

Ordnance experts and military men generally have lately been much interested in a new method of making projectiles. This is the Electric Welding Process, used by the American Projectile Company of Lynn, Mass., and from the success so far achieved, it certainly seems that an important step in advance has been made in the manufacture of steel shell.

The American Projectile Company was organized a little more than a year ago to engage in the practical manufacture of all kinds of projectiles, and having been given contracts by both the navy and army, have, since that time, equipped their shops with the necessary special plant and are now, after a great deal of experimental work, manufacturing on a regular business basis.

All ordnance experts well know the tedious and difficult processes at present used in producing the different kinds of forged steel projectiles. Steel castings for this purpose having long since been abandoned on account of the difficulty in obtaining the desired results and the expense of the castings themselves, it has been, up to the present time, a question of high grade and expensive armor-piercing projectiles and ordinary cast-iron ones for common use. It has been rendered possible, by the invention of electric welding, and is now one of the aims of the American Projectile Company, to produce a forged steel shell at about the same price as it now costs to manufacture the common cast-iron projectile. This is accomplished in the following manner:

1. Hollow steel blooms are cast and from them is rolled out a thick-walled tube, having the approximate finished dimensions of the body of the shell. This is then cut into suitable lengths, and to the short blanks thus made are joined, by electric welding, the head and base of the projectile, which have been previously formed in suitable dies. After this is done, the only machining necessary is turning to gauge on the outside, cutting the rotating band-score and the fuze thread and seat. This projectile is afterwards hardened, and thus is produced in this very cheap manner a thoroughly efficient wrought-steel shell. It will be understood that this is not the high grade armor-piercing shell, but a shell that can be used very efficiently against armor of moderate thickness, and will in other respects fulfil the offices of the common shell, at the same time costing no more than the cast-iron now in use. This, of course, is a very important feature, as it will enable the Government, without any additional cost, to fill the magazines with this much better grade of shell, which may, in time of peace, be used for target practice, etc., and still be on hand for efficient service in case of war. The company are now filling two large contracts for the navy for shell of this character—one for 30-pound projectiles for the 4″ rapid-fire gun and the other for 6″ common shell.

Figure 1 illustrates the formation of this projectile, although in this illustration the midships section of tubing should be longer and the head and base pieces proportionately short. To understand the simplicity of the welding operation, it must be understood that it is only necessary to place these three pieces in contact, one above the other, in an electric welding machine designed for the purpose, and by means of the electric current, which is passed from one pole to the other through the joint which is to be made, the metal at this point is quickly heated to a welding heat, and being kept in close contact by mechanical pressure, so unites at this point as to become homogeneous and equally strong with the rest of the metal. The surplus metal, or burr, formed by the pressure, is mainly forced upwards and is removed in the operation of trueing the body of the shell. The operation of electric welding is so simple that it requires no expert to operate the machine, as any intelligent man can be taught in a very short time all that is necessary to produce a weld impossible in any other way. Furthermore, it is feasible to weld the highest carbon steels, steels that are absolutely unweldable by any other process, one to another, or to weld a high carbon to a low

grade steel, or even to wrought-iron. The importance of this in projectile manufacture will be understood when it is seen that the head of a projectile may be made of high grade expensive steel. and as much of the balance as desired of cheaper, softer material. One who understands the difficulties of obtaining a perfect weld when the metal has to be heated in the blacksmith's fire, will fully appreciate the great advantage obtained by this method, where the metal stands fully exposed to view in the open air and comes in contact with no impurities whatever, where the heat can be checked at any desired moment by the simple movement of a lever, and regulated as easily as the turning off or on of steam or air pressure.

These remarks apply to the ordinary operations of welding, but of course there are many forms which are practically impossible to the smith, and among them the tubular sections used in the manufacture of projectiles. The following will illustrate the strength of a weld of high carbon steel:

A six-pounder armor-piercing shell, fired at a recent test, slapped or "key-holed" slightly on striking the plate. It, however, passed through a 4-inch iron plate whole, and when recovered it was found to be slightly bent directly at the region of the weld. The snap, as the shell straightened itself in the plate, had been so great that the square head of a brass plug, which was screwed into the fuze-hole, had actually been broken short off by the blow, leaving the threaded portion in the hole. Of course, this great strain, as shown by the bend, came directly on the section in which the weld was located, and this showed not the slightest sign of fracture.

FIG. 1.

FIG. 2.

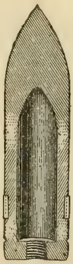


FIG. 3.

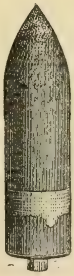


FIG. 4.

The armor-piercing projectiles of this size are being manufactured in two pieces, as shown in figure 2, and in section in figure 3. In this case no tubing is used. Figure 4 shows one of these projectiles that has been fired through a 4-inch armor-plate. One of the marked peculiarities of these armor-piercing projectiles is the following:

The head section is hardened uniformly all over; the base section is not hardened at all. When the two pieces are joined by the electric welding, one of the features of which is limiting the heat to a short distance on either side of the joint, the shell is placed with a portion of the head in cold water, and thus the heat from the weld draws the temper gradually toward the point, thus leaving the base unhardened, and from it tapering to the necessary hardness at the point. Aside from this simple method of drawing the temper gradually toward the point, it will be seen that the hardening of the head alone is a very much less difficult operation than heating and hardening the whole projectile; also, that temper-cracks and other defects may be very easily distinguished in this portion of the shell before the base is welded on. This is considered one of the very important features covered by the patents of this company.

Another style of projectile now being manufactured is the shrapnel, for the army 3.2-inch field-piece, illustrated in section in figure 5 and in detail in figures 6, 7, 8, 9 and 10—figure 6 being the head forging, figure 7 the tubular midships section, figure 8 the steel diaphragm and central tube, forming, respectively, the powder chamber and the passage from the point fuze to it; figure 9 the base forging, showing the shoulder on which the diaphragm rests, and figure 10 the copper rotating band, which is afterwards shown pressed on the shell in figure 5. The method of making this shrapnel is as follows:

The base piece and tube, figures 9 and 7, are placed in contact in the welding machine and joined together, forming a deep cup; while the weld is still hot, the diaphragm and tube are dropped into it so that the former rests on the shoulder of the powder chamber. The weld is then lightly swaged, thus locating the diaphragm firmly in place. Next the head forging is placed in contact with the open end of the tube and with the small central tube passing into the fuze-hole. This is then similarly joined by an electric weld. Afterwards the upper end of the small tube is crimped over a slight shoulder in the bottom of the fuze-hole. The outside of the shrapnel is then turned to gauge. A small hole is drilled in the head, communicating with the interior cavity; through this the shrapnel is filled with the neces-

sary bullets; next the matrix is poured in, and finally the hole is closed by a small plug which is screwed into place. Before the case is filled with the bullets and matrix it is hardened to give increased rigidity to the thin walls and to increase the number of fragments into which the case will burst. In trial, these shrapnel have given most excellent results.

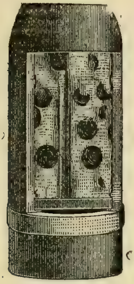


FIG. 5.

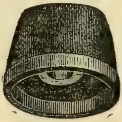


FIG. 6.

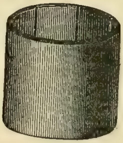


FIG. 7.

FIG. 8.

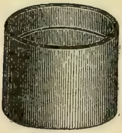


FIG. 9.

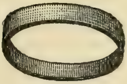


FIG. 10.

So far, the largest shell being manufactured by the American Projectile Company are the 6-inch naval common shell above referred to. These weigh, empty, 94 pounds, and have an outside diameter of 5.96 inches, with a thickness of wall of 0.95 of an inch. It is expected, in the near future, that the company will undertake the manufacture of very much larger projectiles, as the only limit seems to be the possibility of obtaining the necessary tube, and arrangements are now being made to have this produced of the necessary dimensions to make as large as 12-inch shell.

It is believed that projectiles of the character described in the beginning of this article will be peculiarly adapted for use in mortar

service against deck armor, etc., as they will have all the advantages of armor-piercing projectiles for penetrating that thickness of armor, and can be produced at a fraction of the cost of the more expensive missiles.

In conclusion, a brief description of one of the welding machines may be interesting. Figure 11 shows one devoted to small size projectiles, such as the 6-pounder armor-piercing and common shell. It stands high from the ground to enable the operator's helper to place and remove the shell being operated on from beneath. After placing the separate pieces of the shell in the machine from the under side, a movement of the hand-lever in front of the operator throws in a set of hydraulic contacts through which the electric current passes to the portions of the shell they enclose. This current is obtained by transforming the primary current of 200 volts and about 250 amperes into a current of ½ a volt and consequently enormous quantity. The current is perfectly controlled by a switch, operated by a foot-lever and in connection with a reactive coil. To carry this great current, heavy copper castings are necessary, which are kept cool by water-jackets and a continuous circulation of water. These water connections, for cooling and for pressure purposes, are shown by the numbers of pipes and tubes at the top of the machine. To give the necessary pressing together when the shell is at the welding heat, another hydraulic cylinder is provided. This is controlled by a lever conveniently placed. After the weld is finished, the assistant quickly carries the shell to a small hammer, where the burr is lightly swaged. It is then placed, head downward, in a shallow vat, to keep the temper from drawing out of the point.

The general construction of all the welding machines is extremely simple, the only thing requiring any particular care being to insure proper electrical contacts on the shell. This cut is taken from a photograph, and shows the operator holding the freshly-welded shell on its jig. This will give an idea of the local limit of the heat after the weld has been made.

In welding larger projectiles, another style of machine is used. This is illustrated by Figure 12. In this case the parts to be welded are placed upon the head of an hydraulic ram, which moves them upward into position as shown. The electric connection in this case is also made by hydraulic plungers in electrical connection with the induction coils, and they are caused to move in or out by means of a valve operated by the T-shaped handle shown near the top. A

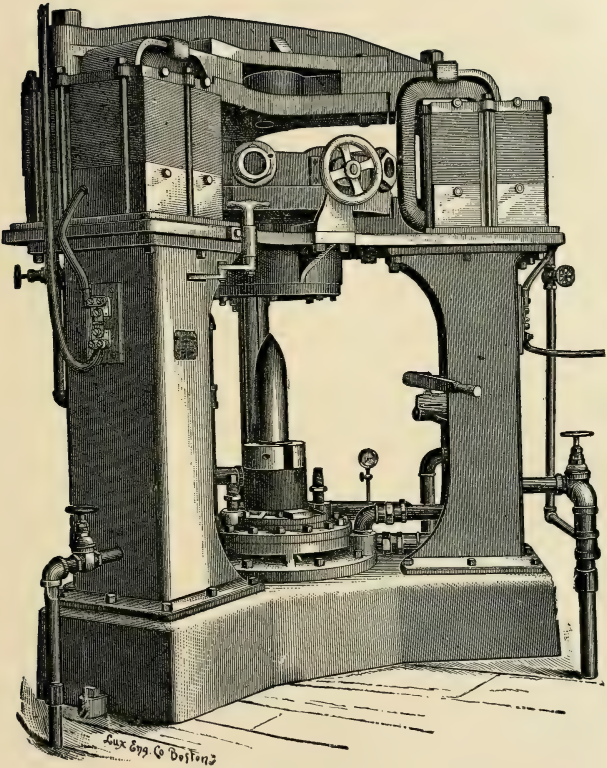


FIG. 12.

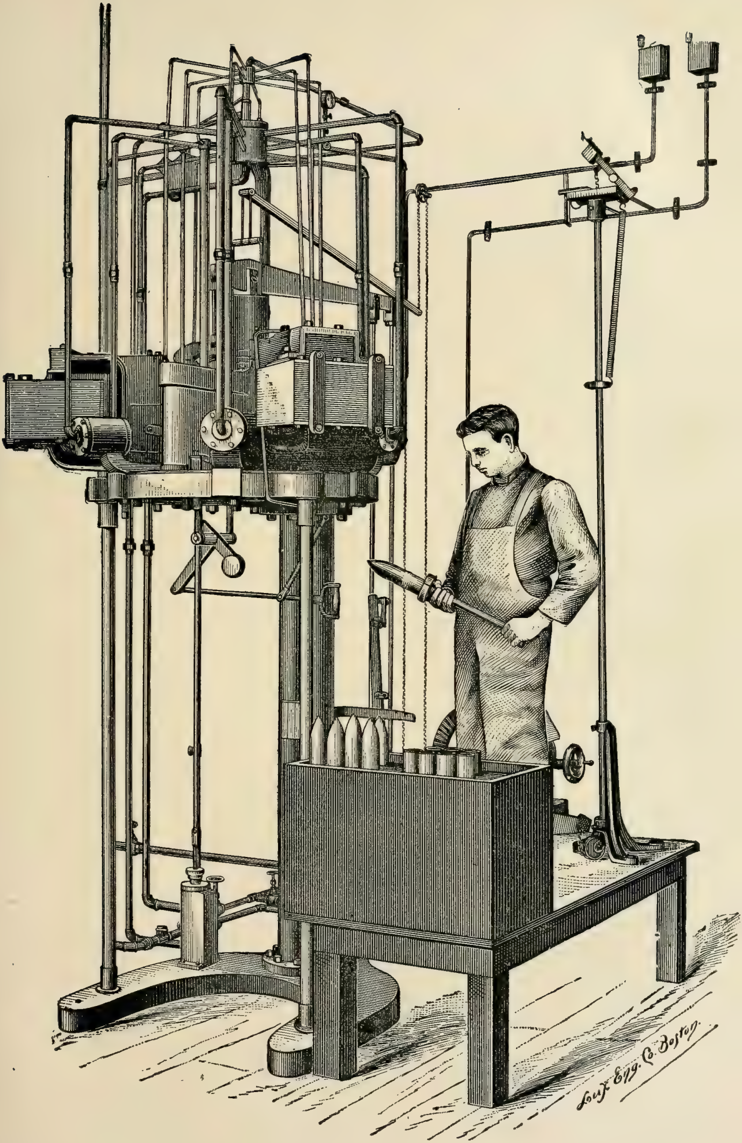


FIG. 11.

foot-lever actuates the switch, as in the smaller welding machine and a hand-lever shown on the right of the machine controls the upward pressure. The work at present being done by this machine is a section of eight square inches per weld, the operation being completed in 3½ minutes.

In describing the tubular shell of the 4-inch type it should have been stated that these projectiles have already been successfully tried against thin armor and have exceeded in results what was expected of them.

A great number of special machines and appliances necessary for making this business a practical and financial success have been designed by Lieutenant William Maxwell Wood, U. S. N., who is also the inventor of this system of manufacturing projectiles.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE INFLUENCE OF RANGE-FINDERS UPON MODERN ORDNANCE, GUNNERY, AND WAR-SHIP CONSTRUCTION.

By Lieutenant Albert Gleaves, U. S. Navy.

It is believed that the introduction of a trustworthy naval range-finder will lessen the necessity of extremely long guns, change the present disposition of the battery, modify the construction of war-ships, and materially alter the conduct of the naval battles of the future.

For more than twenty years guns have been increasing in length of bore. Previous to 1879 twenty-caliber guns with a muzzle velocity of 1400 f. s. or 1500 f. s. were considered quite good enough; but the introduction of hard armor of great thickness called for greater penetrative power in the guns, and this has led by successive steps to the present high-power rifles, 45 and 50 calibers in length, with initial velocities as great as 2800 f. s.

The use of these guns, especially on board ship, is attended with disadvantages which cannot be overlooked. Their increased weight, the greater probability of being disabled by having the chase struck by an enemy's shot, the increased difficulty in the construction of the carriage and in handling the gun, and the extra cost, are serious considerations. Primarily, these guns were designed to obtain greater penetration and accuracy; for in cases where the range is uncertain, the flatter the trajectory the greater the accuracy of fire. If, however, the range is accurately known at every instant, and the gun-captains are kept constantly informed of the exact distance and bearing of the enemy, will the very long guns make better practice than the ordinary gun of 30 calibers? Compare the targets made by the old-fashioned smoothbores with those made by the new guns, and it

will be seen that the great difference in accuracy between the guns is not realized in actual service.

Doubtless it would seem absurd to state that for all practical purposes the 30-caliber gun is as accurate as one ten or fifteen calibers longer, but it is hoped to prove this by the following illustration, in which, for the purpose of comparison, a 6-inch B. L. R. firing a full charge (2000 f. s.) is taken to represent the very flat trajectory gun, and the same caliber gun with reduced charge (1700 f. s.) stands for the other. Let us suppose that both guns are laid upon the same point in a vertical target at a known distance. The elevations of the guns will of course be different, but the lines of sight will pass through the same point on the target. Now, if by reason of rolling or some other derangement both lines of sight are thrown off the point aimed at, and at the same time both guns are fired simultaneously, neglecting the errors of the gun, the two shots will have the same error on the vertical target; that is, their points of impact will be identical on the target; in other words, both shots will pass through the same point. That is, the higher power gun will do no better shooting in the vertical target than the other, and its range error will be much greater. A little reflection will show that this is true, and an examination of the formula

$$y = x \tan \theta - \frac{Cx}{2 \cos^2 \theta}\left[\frac{A_2 - A_v}{S_2 - S_v} - I_v\right]$$

in which y is the vertical ordinate of the trajectory at the range x, will prove it.

The advantage of long guns, then, seems to depend wholly upon the question of penetration.

The penetration of the 6-inch B.L.R. of 30 calibers is estimated to be 10.27″ of steel at the muzzle and 7.57″ at 1500 yards; the corresponding penetrations of the 6-inch B.L.R. of 40 calibers are 11.38″ and 8.39″ respectively. But there are not a half-dozen ships afloat that will keep out the 30-caliber shell and not keep out those of the 40-caliber guns.

Comparing the 30-*caliber* 6-*inch B. L. R.* (2000 *f. s.*) *with the* 40-*caliber* 6-*inch* (2150 *f. s.*), *we find that the penetration has been increased about* 10 *per cent, and that the power of the gun referred to foot-tons per inch of the shot's circumference has been increased about* 16 *per cent; but on the other hand, the weight of the gun has been increased* 25 *per cent, and the efficiency of the gun decreased* PER TON WEIGHT OF GUN *about* 8 *per cent.*

It is generally believed that the fighting range during the greater part of an engagement at sea will be without range-finders about 1000 or 1200 yards. And yet our high-power guns, even if 30 calibers, range 7000, 8000 and 10,000 yards. Are we then to be compelled to fight at 1000 or 1200 yards and throw away the immense advantage of such ranges? As long as we have to depend upon individual estimation of distance in the excitement of action when smoke obscures the view it will be necessary to do this, for at 4000 yards the average error in judging distance even on shore is said to be 1000 yards. The possession of a range-finder, however, enables us to utilize the full effect and power of the gun's reach. Knowing the distance accurately extends the fighting range, and having a moderately high-power gun, this will be only limited by the distance at which the gunners can keep their sights on the target.

Many interesting and important considerations follow the great increase in the fighting range. It will decide the question of disposition of weight of metal allotted for guns in favor of large calibers, which means a fewer number of heavy guns rather than a greater number of lighter guns. Discussing the subject of disposition of metal for guns, Lieutenant Meigs says: "The question is one of range. At what range are modern vessels, armored or unarmored, expected to fight? A logical solution of the question of the defensive and offensive power of a ship of war cannot be reached without assuming what the fighting range will be."

In putting our metal into large-bore guns we of course sacrifice very flat trajectories and penetrative power, but we can afford to do this if we increase the fighting range to 3000, 4000, or possibly 5000 yards, and at the same time increase the weight of the shell. If ships engage each other at 1000 yards, more or less, it is obvious why flat trajectories are essential; the "point blank" range of modern guns is 1000 yards, or, to put it in another way, these guns will strike a target 12 feet high up to 1000 yards when the sight-bar is down, and therefore it would not be necessary to touch the sight-bar as long as this range is maintained.

Increasing the range will tend to decrease the side armor of a ship and the thickness of protection in the wake of the battery, since increase of distance means decrease of striking velocity; although, owing to the fire becoming curved, there will be an increase in the thickness of horizontal armor. This saving in thickness of armor will allow its greater distribution for a given total weight; or an

addition to the weight of gun-metal and ammunition; or, if these be deemed sufficient already, to the weight of coal carried.

"The tactical value of a gun depends upon the number of shots it can put in a standard target in a fixed interval of time, upon its power of penetrating or smashing targets, and upon its mine power. . . . The first of these qualities—that of putting a large number of shot into a target in a given time—belongs in a higher degree to small than large guns, because, although the larger shot are usually less deviated by accidents of flight, yet they cannot be delivered so rapidly from the same total weight of metal in guns. The second—that of penetrating and smashing targets—increases with the caliber. And the mine power of shells increases much more rapidly with the caliber—nearly as its cube." *

Thus we see that the gun which satisfies the range-finder possesses two of the three factors which are of the highest tactical value. With regard to the third—rapidity of fire—it must be remembered that in long-range sea engagements the fire will naturally slacken and therefore render this quality of the gun of less importance than it has had heretofore. Again, reducing the speed of firing will give the smoke time to drift away, the target will be more plainly visible and the firing will become more deliberate, a condition most favorable to economy of ammunition.

Now as to the disposition of the guns, and in arranging them to suit the changed conditions imposed by the range-finder, we will find another return to an old order, illustrating the shifting and unsettled nature of artillery questions.

After shell-guns were introduced the battery was dispersed, to minimize as much as possible the effects of a burst between decks. The Gloire (1858), Warrior (1859), and Minotaur (1861), the Italian Formidable (1860), and the Russian Petropavloski (1861) are examples of this disposition of guns. As armor increased, however, in thickness and became harder, the defense gained so rapidly that guns were collected together in turrets, central casemates and armored citadels. This period of naval construction is typified in such ships as the Alexandria (1873), with 12 inches of iron armor; Inflexible (1874), with 24 inches of iron; the French Tempête and the Italian Duilio (1873) with 21.3 inches of steel armor.

The development of rapid-fire guns and the introduction of high-explosive shells made it necessary to again change the battery by

* Naval Gunnery—Meigs. Gen. Information Series, No. VIII, p. 176.

separating the gun-positions as much as possible, and examples of this are seen in the ships built in the last ten years, in such battle-ships as the Collingwood, Victoria, and Trafalgar, the French Marceau and Hoche, and the Italian Re Umberto, and in cruisers like the Warspite, Dupuy du Lôme, and the New York. Nothing in the chequered history of ships and guns is more clearly defined than the periods of battery dispersion and assemblage.

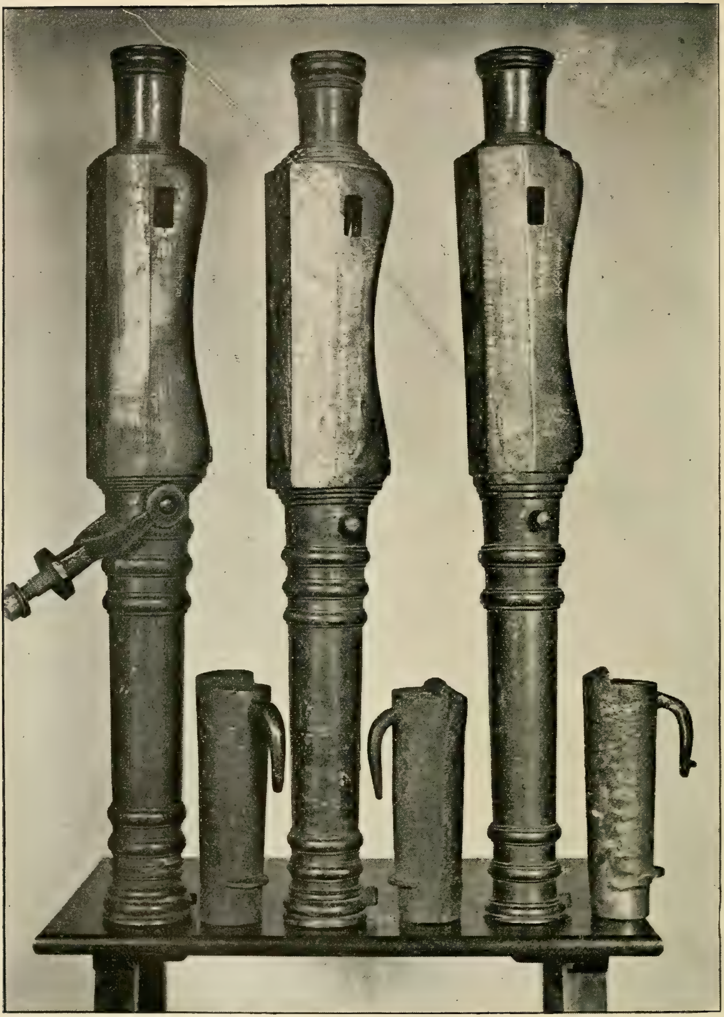
The range-finders will revive the era of citadels, central casemates and turrets. This follows from two facts incident to long-range actions. First, rapid-fire and machine guns will necessarily play a much less important part in long than in short ranges,—indeed, battles will be fought out of the range of the latter altogether; and second, the chance of obtaining a burst of a high-explosive shell between decks is materially decreased. The advantages of bringing the guns as close together as possible, thereby avoiding the inconveniences of supplying and controlling a widely separated battery, can once more be adopted.

In these days of high-speed ships, the captain who knows the range would have a decided and dangerous advantage over an opponent who was feeling for it; in fact, by skillful manœuvring he might draw much of his ammunition without injury to himself and at the same time be pouring in a well-directed and deliberate fire.

The effect of the range-finder upon the battle tactics of fleets will be to prevent mêlées; at least there will no longer be any cause for a rush and an entanglement of opposing ships, until one ship has been so disabled that her antagonist can rush on her and ram her. The action, as in the case of the duel, will be fought at long range and be decided by good gunnery. Rams and torpedo-boats will have their part to play, too, but instead of the attack opening with a dash of torpedo-boats, these with the rams will be held in reserve to give the *coup de main* to a badly wounded or disabled adversary.

These are some of the tactical changes and effects that it is thought the range-finder will work upon existing methods and ideas. But they are not all; every innovation is attended by consequences not seen at first, and doubtless when every ship in the service is supplied with one of these instruments, and "range-finding" takes its place in the regular routine of exercises, changes not thought of now and not anticipated will be gradually developed. In fact, a careful consideration of the subject by the writer for some months has suggested to

him consequences so sweeping and radical that he hesitates to express them all. He therefore submits this paper more as a tentative endeavor to open up a hitherto unexplored domain, than as a complete or finished essay, in the hope that the commanding importance of the subject will induce others to undertake its thorough and complete discussion.



U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES ON THE DATE OF MANUFACTURE OF THE THREE GUNS AT THE U. S. NAVAL ACADEMY, CAPTURED IN COREA BY REAR-ADMIRAL JOHN RODGERS, U. S. N.

By Thomas Wm. Clarke.

One of these three guns is of a slightly ruder type than the other two. Both the others contain a mechanical feature which this ruder gun lacks, the ratchet on the under-side of the bottom of the boxing of the breech-cavity for engaging the point of an elevating pawl when in battery. A convenient mechanical contrivance like this could not have been introduced into ordnance and then omitted from professional work without providing a substitute, unless the traditions and models of former work had been lost.

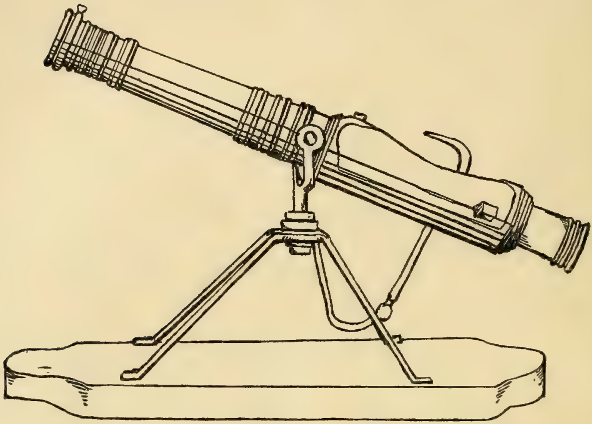
Chinese practice, still more than European, would respect the ancient and approved ways, and anybody would leave the better structure alone.

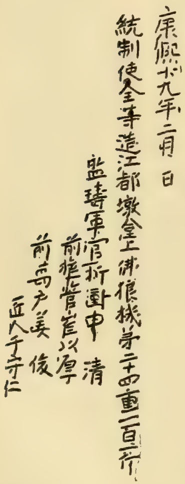
We may then, at this stage of the inquiry, and simply to settle the order of reading from latest to earliest, regard the gun without the ratchet as of earlier date than the guns with ratchets.

THE GUN OF 1680.*

All three guns bear inscriptions which have been translated by the accomplished scholar Wong-Chin-Foo, of New York. One of those with ratchets presents the longest inscription—55 characters. This reads:

* In the cut opposite, the left-hand gun, with swivel and nut, is the gun of 1680, the middle one is the gun of 1313, and the one on the right is the gun of 1665. The cartridge blocks are of cast iron and much honeycombed.





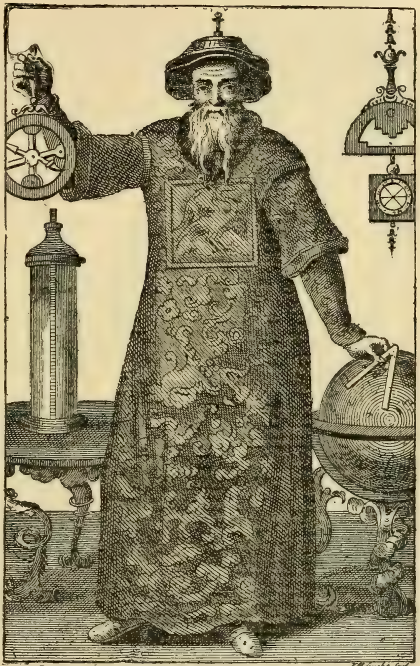
(Col. 1 at right) K'ang-Hi, 19 year 2 month day. (Col. 2) Tung-Chi-Shi whole company built *for* Kiang-do-dun *its* metal top, Fulang-khi number 24 weight one hundred and one catties. (Col. 3) Gien-Chi-Gwen-Gwan-Ja (The casting General, superintendent acting) Chung Shin Ching. (Col. 4) Chief managing official Chow-Yi-Ho. (Col. 5) General of division Kiang-Chun. (Col. 6) Master workman Yu-Shun-Jen.

K'ang-Hi was the regnal title employed by the second Emperor of the present dynasty. This title is indicated in this inscription as an imperial regnal title by having its first character slightly above the rest of the inscription; a curious etiquette which prevails in inscriptions, in proclamations, and in formal official documents, but not always in printed books. It is shown, however, in a page of a printed book which illustrates this article. There are now strict and arbitrary rules for this, going much further than mere elevations of single characters. The present etiquette requires full

spacing in the elevations. The present rules are recent and of this century. They are analogous to the black and red ink formalities of army papers in the United States.

This Emperor came to the throne in 1662, when eight years old. His nineteenth year would begin in February, 1680. He reigned over sixty years, and on his decease received the temple name of Shen-Tsu-Jen-Hwang-Ti, by which he is spoken of in books written after his death.

He was educated in part by Father Adam Schaal, a Jesuit missionary who had been his father's tutor, and who held, on the demise of the crown, official position in the board of mathematicians.



Father Adam Schaal, Chinese Missionary.

Under the regency which ensued, and which lasted about four years, there was a religious, perhaps a national reaction. The missionaries fell into disgrace and were imprisoned, but were released and restored to favor in or soon after A. D. 1666, when the Emperor began to govern as well as to reign.

For a century and a half the one undisputed Chinese fact among Europeans has been, that at this period the autochthonous skill of the Chinaman in ordnance and artillery was very limited, if not quite lacking. Nothing less than most convincing proofs can shake this conclusion. This proof is at Annapolis.

Father Duhalde relates that there were during his residence in China, somewhat later than this date, some bombards at the gates of Nanking and some "Pattereroes" in the buildings on the sea-coast, but not skill enough in China to make use of them. In 1621 the city of Macao gave the emperor, Tien-Ki, three guns; to manage which, Portuguese engineers were taken into Chinese service. These Macao guns proved terrifying to Tartars, so that in A.D. 1636, under the last Ming Emperor, during the Tartar invasion, at a time when there was a persecution of Christians for the purification of the empire, and to appease the divine wrath, Father Schaal was entrapped into admitting that he knew the European method of casting guns, and was ordered by the Emperor, Tsung Cheng, to instruct workmen in the art, and was assigned a proper place near the palace and allowed assistants from the imperial retinue.

Father Ferdinando Verbiest, Chinese Missionary.

Though not directly stated by contemporary European writers, it is believed by Williams and others that some guns were produced by Father Schaal. Duhalde says: "Use was made of this Means to introduce into the Empire a great number of Evangelical Workmen." Whatever was inaugurated by Father Schaal was but temporary, and his laboratory, if any was formed, had been broken up before 1670.

In 1665, Fathers Schaal and Verbiest were imprisoned in fetters, and Father Schaal was tried for his life and convicted, but he was released, pardoned, and died of a good old age, August 15, 1666.

While in prison, a controversy arose as to the accuracy of the official almanac, and the Jesuits, excepting Father Schaal, were taken out of prison, brought before the Emperor, and ordered to make a series of instrumental tests of the accuracy of its calculations. The date of this is not given, but it must have been before August, 1666. On proving the error of the official astronomers, Verbiest was ordered to find out the errors and correct the work, and another series of observations was made, the result of which was that in A. D. 1669 Father Verbiest became President of the Board of Mathematics. After this he caused to be made several altitude, azimuth, equinoctial and other measuring instruments, quadrants, sextants, and a celestial globe of great weight and size, from cast brass, with fine modeling and with very decorative features in the Chinese style.

After this work had been done, its mechanical excellence attracted the attention of the Board of War, probably about 1678, because about that time he finished his work on the calendar and presented his book of calculations to the Emperor, and was promoted in rank and awarded a title.

The Board of War obtained an order on Verbiest to instruct workmen in the art of cannon-casting, and "he cast 130 pieces with great success."

After this the Board obtained another order on Verbiest, by his Chinese title of Nan-hoai-jin, given him in 1678, ordering the casting of 320 pieces of various calibers and of the European fashion, and that he should oversee the work. On February 11, 1681, he delivered the models, which were approved, and the Board of Works was ordered to furnish all that was necessary for the work. The job took over a year. Many difficulties were encountered, attributed to the jealousy of courtiers. One of these troubles enables us to say that these guns were muzzle-loaders. An attempt was made to disable a gun by wedging a shot in the bore. Father Verbiest removed it by the now well-known scheme of loading with powder at the touch-hole and firing out the shot. All of Verbiest's guns were blessed and engraved with saints' names in the foundery, and were engraved with proper characters traced by the Father's own hand.

The proof of these guns was made in 1682, and twenty-three thousand practice-shots were fired from them. Father Verbiest was

again promoted in official rank to a position equivalent to that of "Viceroys who have deserved well in their government."

On this occasion the Emperor said to Father Verbiest, "The cannons that you made the last year were very serviceable against the rebels, and I am well satisfied with your services," and he gave the Father his furred vest and gown.

KANG HI.

This dates Father Verbiest's gun-founding work in A. D. 1680 to 1682. It was done in Verbiest's own foundery near the palace. It was muzzle-loading work, and was marked with saints' names.

Neither of our three breech-loaders is so marked, hence neither can be a Jesuit gun of Verbiest's time. They present a special variety of the familiar type of *pedrero*, of which the Cortes gun now at Annapolis, made probably as early as 1474, is another variety. They are what is called by the English writers of the Tudor and Stuart and early Georgian periods "petereroes," a word which is spelt with a great variety of combinations of t's, e's, r's and a's. Such swivels were familiar to Europeans in the sixteenth and seventeenth centuries, as shown by the numerous illustrations of them collected by Favé for the late Emperor Napoleon's work on Artillery. Duhalde does not claim that they were introduced by the missionaries, but on the contrary concedes them to have had a more ancient origin.*

* As Duhalde is not divided into numbered chapters, and as there are several editions, some in two and some in four volumes, and of various dimensions of page, it has not been practicable to refer to this authority at each citation, but a compilation of the dates given in the section on "Cang Hi," in the chapters on "Military Government," etc., "Of the Nobility," and "Of their Astronomy," shows that the dates given above are substantially accurate. The copy consulted was Brookes' translation, 3d edition, London, 1741, 4 vols. 12mo.

Duhalde also in his chapter on the History of Corea relates that in the 26th year of Wan-Li (A. D. 1598) the Chinese commander had a cannon shot off as a signal for springing a treacherous ambuscade contrived against the Japanese general, Hing-Chang. Griffis' "Mikado's Empire," p. 246, speaks of a breech-loading Japanese cannon of this period — the Japanese invasion of Corea — still preserved at Kioto. Even earlier than this, one of the generals in Corea had his horse killed by a "canon shot."

We are now prepared to analyze this inscription. The gun was made about March, 1680, for the Chinese year began in February. Its destination was the metal top of the fort (Dun) at Kiang-Tu (the river capital). It will not be too hazardous a conjecture to say this was a barbette battery at Ngan Kiang Fu, now capital of Ngan-Hwei, then the western capital of Kiang-Nan. There was a large garrison there, a strong and notable fort, and the times required this point to be vigorously maintained. Twice before in the history of China had the control of Poyang Lake and of the river-bend close by seemed decisive of the fate of a dynasty,— when the Mongols obtained and when they lost the empire. In 1680, to the south and southwest of this pass, the organized armies of a Chinese revolted vassal who had assumed the yellow vestments were in full force and concentration, and the Tartar generals had got control of the sea-coast and were pushing inland along the southern frontier towards Yunnan, in order to isolate the revolt in an uncultivated mining country, where lack of supplies would in the end compel the rebel chief to risk an engagement on the field of his adversaries' choice or lose his army by famine or desertion. The fort at the Poyang Lake pass is a likely, but not certain, original destination of this piece.

The personages who were responsible for the enterprise were Tung Chi Shi Tsien Zhe. The last two characters clearly signify the whole body or company. Shi is a character which implies civil magistracy. Tung Chi is to-day, as Mr. Mayers' manual of Chinese Governmental Titles informs us, the colloquial designation of the chief military officer of a single province or the second military officer of a viceroyalty. The second column can then be paraphrased in English thus: "The provincial general-in-chief and the whole body of civil magistrates (of the western government of Kiang Nan) built (for) the barbette battery at Ngan-Kiang-Fu, Fulangkhi Number 24, weight one hundred and one catties."

The next notable thing is the height of the succeeding columns.

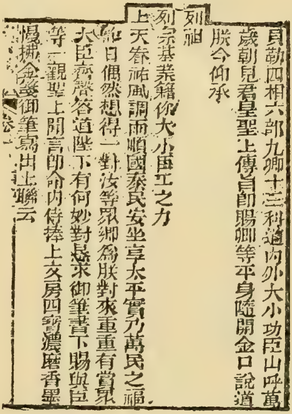
The third column begins abreast of the seventh character of the second. The fourth and fifth begin abreast of the eleventh character of the second column and the fourth of the third. The third, fourth and fifth columns end about even. The sixth has its top two characters lower down than the top of the fifth column and ends a character lower. These are signatory columns, and show that one functionary was of considerably higher rank than all the others, and one of considerably lower rank.

The workman who practically did the work was Ju-Shun-Jen (Col. 6). The principal supervisor was a military mandarin, acting as superintendent, named Chung-Shen-Ching (Col. 3). The next in authority was a Tseng-Twan-Gwan (chief managing magistrate). He was probably subordinate to the Board of Works and may be called the principal director, Chow-Yi-Ho (Col. 4). The third inspector was entitled Tseng-Wan-Hu, and was named Kiang-Zin. This title translates chief of 10,000 families. One must not, however, in Chinese, any more than in English, over-analyze syllabic constituents of a word or phrase. By itself the word "sloop" signifies a fore-and-aft rigged vessel with one mast and a bowsprit, which has her head-sail in one piece, with its tack made fast to the outer end of the bowsprit. "Sloop-of-war" designates a vessel which has none of these characteristics. The English Major-General corresponds to the French General of Brigade. The American Major-General corresponds to the French General of Division. In gunnery we find mentioned in English about a century ago "murderers" and "murdering pieces," as well as "petereroes." They refer to the same sort of gun, a light swivel. Just as the French *perrier* and the Spanish *pedrero* have lost their relation with stone shot and now signify only the swivel mounting of the piece, so the coupling by the Spaniard of a pair of swivels into the masculine and feminine or fatherly and motherly relation of *padrero* and *madrero* (motherling or pet) gave Jack Barnacle a chance to convert a Spanish jest into an English special noun of appropriate sense for its retained sound, and Diego's mother's darling was transformed, by the English mouth struggling with a Spanish word, into a truculent assassin.

Thus, while the title Wan-Hu recalls the Mongol national organization on a plan of decimal family groups, which forms the basis of the early Hussar or hundredth-man levy of Hungary, and of the Cossack contingent of Russia of to-day, so the families which averaged a soldier apiece have ceased in this title to be an exact description,

the myriad has become numerically vague, and the Wan-Hu chief signifies in a society, which has passed from the nomad to the sedentary stage of civilization, such a military officer as would command a force equal to that furnished by 10,000 nomad families. It will not be unsafe to consider this title as that of a Tartar General of Division, or chief of a banner.

This gun is number 24, and its weight is 101 catties (about 135 pounds). The sort of weapon is Fulangkhi. Fulang is now used colloquially to designate the French. It is also used for foreigners generally, as Frank has been used in the Levant for centuries. The selection of characters to form this word would always suggest to the educated Chinaman the ideas of barbarian, spadassin, and beast, while the syllable *Khi* is so formed as to suggest manufacture, well contrived and weapon.



員勳四相六部九卿十三科道內外大小功臣山呼萬
歲朝見君皇聖上傳旨即賜卿等平身隨開金口說道
朕今仰承
列祖
列宗基業籍你大小臣工之力
上天眷祐風調雨順國泰民安坐享太平實乃萬民之福
朕日偶然想得一對汝等衆卿為朕對來重重有賞衆
大臣齊聲答道陛下有何妙對奏來御筆書下賜與臣
等一觀聖上開言即命內侍捧上文房四寶濃磨香墨
慢撚金毫御筆寫出上聯云

PAGE OF BOOK TO ILLUSTRATE ELEVATION OF CHARACTERS.
(See p. 266.)

When the reign K'ang Hi began, the boy Emperor had by no means a well-established throne, far less a prospect of the grandeur and power which he attained. While his court exercised direct sway over part of the provinces north of the Yang-tzee and over one or two south of that river, three Chinese vassal-kings, who owed him little more than homage for investiture, maintained large independent armies, held most of the provinces south of the Yang-tzee and west of the Yellow river, and controlled the tea crop, most of the silk crop, a large part of the rice crop, and all the foreign commerce. Each was only less powerful than the Emperor. The three, and probably either two — the other neutral—could overmatch him. The famous Cheng-Chang-Kung was established at Formosa as a sea king, and ravaged the coasts of the imperial provinces so that they were depopulated for three leagues inland and the sea fishery broken up. The Emperor's court was seamed with gentile and sectarian dissensions. The calendar was disgracefully erroneous,

and was proved so in 1666 in the presence of the Emperor, with improvised instruments got up over night by men just out of prison. After four years of regency this boy of twelve dismissed his tutors and guardians and took the scepter himself.

He had been born to good luck. The great Formosa prince had died the year of K'ang Hi's accession. Cheng King-Mai, with less warlike tastes than his father, kept the peace of the sea for ten years.

In 1673 an attempt was made to organize a great gentile movement of China for the Chinese. Wu-San-Gwei, who had a powerful army trained in civil war and fresh from the conquest of a secure frontier on the side of Burmah, put himself at the head of it. He was the most powerful of the vassal-kings and assumed some of the imperial functions. Keng-Tsing-Chung, who had just succeeded his father in Fokien, and Shang-Ko-Ho of Kwang-Tung, the other two vassal-kings, were in the combination, and Cheng-King-Mai sailed to join his forces with those of Fokien, of which he was a born subject. Wu-San-Gwei promptly invaded and occupied the imperial provinces near him. A few questions of etiquette spoiled the combination. The conspirators had not agreed in advance about the yellow vestments or their own respective precedency. Cheng-King-Mai failed to be received at Fokien as an equal and independent prince. Shang-Ko-Ho of Kwang-Tung preferred a vassalage which had known limits to an undefined and vague future, and refused to change his allegiance prematurely.

Wu-San-Gwai AD1643 to 1668.
from a Chinese print

The Prince of Formosa, stung by the affront to the past of his family, by force of arms drove Keng-Tsing-Chung to submit to the Tartar and then retired to his island to sulk and die. The armies of Kwang-Tung and of Fokien were soon arrayed under imperial

generals against the Prince of Western Peace, and that aged Chinese patriot died in 1679. Two years later the rebellion was entirely suppressed. The son of Wu-San-Gwei, who had been proclaimed Emperor, committed suicide. Shang-Chi-Sin, who had succeeded his father on the latter's suicide in 1676, in 1680 received the imperial sentence of death, which was mitigated by the imperial present of a red silk cord and a sign-manual permitting suicide, for thus his royalty was acknowledged while his treason was punished. He obeyed the sentence and hanged himself in red silk like a king. Keng-Tsing-Chung, of Fokien, who had been too strong to punish in 1674 when the dynasty was in danger, was executed with ignominy in 1681 and his brothers were beheaded. Conflicting ambitions had swamped a conspiracy which if combined had been stronger than the empire.

From this date on, to the end of his almost unequaled reign of sixty years in 1722, the Emperor showed himself a vigorous, enterprising and intelligent prince. He was athletic in person and proud of his strength and skill as an archer. He was a bold huntsman and did not hesitate to encounter the tiger with sword and spear. He studied and promoted the arts and sciences. He was versed in the literature of his empire, and personally and almost daily supervised the compilation of the great Chinese dictionary, a work unrivaled in western nations till the publication of the encyclopedic dictionaries of the present day. He instituted an elaborate topographical survey of the empire, and caused to be collected statistics of its resources and requirements. He re-established, revised and regulated a system of posts, post-roads and signal-stations for visual telegraphy, managed by squads of soldiers always on duty. He repelled from the borders of the empire the dangerous tribes of barbarians, and established the bounds and limits of the nomads across the frontier, so that friendly clans and tribes attached to the fortunes of China by similarity of race, by family relations, by social rites, by ties of hospitality, and by the ambition or interests of chiefs, should range along the boundary and the jealous and ill-disposed be kept at a distance. Corea, Tonquin and Annam sent him tribute. Thibet yielded to his arms and received his frontier garrisons. He negotiated with foreign powers, had treaty relations with Holland, Russia, Portugal and the Pope, and had a correspondence with France. He pacified the empire, readjusted the boundaries of the provinces, and fixed the present administrative system with its all-pervading dual

executive staff of functionaries of the dominant and subordinate races. His manners were popular, affable and dignified. He was an economist and an able financier. He utilized the army in the postal service, as a rural and municipal police, as exterminators of beasts of prey, as gatherers of the products of the deserts and the forests, and made the soldiers cultivate on military reservations some part of their subsistence. He paid great attention to justice. Most of this great work was done later than 1681.

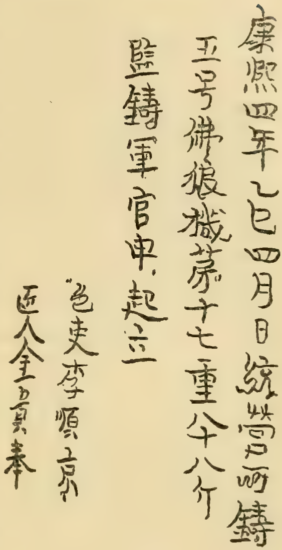
We have seen from the dates that it was almost impossible that Father Verbiest should have made this gun of 1680, but that if he did it was of the first lot of 130. Doubt can only arise from the very explicit statement of the Jesuit fathers that the Board of War sought the aid of the fathers for instruction in the art, as if they were ignorant of it.

Of what were the Chinese ignorant? Certainly not of the art of moulding, melting and pouring copper alloys, for under the Emperor Yung Loh, nearly three centuries before, five great bells had been cast which weighed 120,000 pounds each. Marvellous bronze vases of great size and great bronze lions are spoken of in contemporary works of missionaries who make no mention of any metallurgy of copper save that derived from Europeans. But the plunder of the Summer Palace, with its dated masterpieces, has long convinced Europe that the bronze founder of China has been possessed of great technical skill from generation to generation for about a thousand years. The only things they needed to learn were the shapes to be moulded and the alloy required.

Europeans worked at random in the metallurgy of bronze till the present century, using old metal without quantitative assay or analysis for a large part of their material, and their proportions of copper in guns varies from 75 to 88 per cent, of tin from 7 to 15, of zinc from 5 to 15, and there were usually traces of iron and a notable trace or percentage of lead. The definite mixture of the present century had no place in the arts of Europe before 1800. The Chinese knew the crucible as well as any. They needed most of all a pattern-maker, a designer of new forms of artillery. This they found in Father Verbiest. He did not make breech-loaders.

THE GUN OF 1665.

Let us now turn to the other gun with a ratchet, and see if the gun first under consideration was of the European model introduced by the missionaries.



The inscription reads: K'ang Hi, fourth year Yih Chi, fourth month (*lacuna*) day Tung Ying So cast. (Col. 2) Fifth class Fulangkhi, number 19, weight eighty-eight catties. (Col. 3) Gien-Chi-Gwen-Gwan (casting superintendent general) Shen-Khi-lik. (Col. 4) District Magistrate Li-Shun-Jing. (Col. 5) Master workman Kin-Ngai-Bong.

We have here a different formula. The date is May, A. D. 1665, which is determined by the regnal year, fourth,—1662 being the first,—and also by the cyclical words Yih Chi, which denote the forty-second year of the cycle of sixty then current, of which 1624 was the first year.

At this date, 1665, we are explicitly told by Duhalde, the persecution of the missionaries was at its height. Father Schaall was in prison and was soon afterwards sentenced to death. Father Verbiest and two others were also in prison "loaded with nine chains." This work then, made before Father Verbiest did any bronze casting at all, five years before he cast his first lot of guns, and six years before he delivered his perfected patterns to the Emperor, owes nothing of its technique to him.

The contribution of Father Schaal in and after 1636 to the defensive strength of China is nowhere definitely stated. It is said that the order to do the work was the occasion of importing "evangelical workmen" or missionaries. Father Verbiest's practical results are enumerated, and he was arraigned before Christendom for violating a canon of the Church which forbids Christians to aid infidels in war, and defended himself with the argument that the infidels aided were warring with infidels, and the work done enabled the Christians to attain among these infidels a footing otherwise impossible. No such arraignment of Father Schaall was made, no specification of any but the evangelical results of his work is found. He is not cited as a precedent by Verbiest.

Schaal's work in the last years of the Ming dynasty was, therefore, without consequence in the ordnance department of China.

Yet in 1665, when he was in prison, we find five classes of "Fulangkhi" in use, we find them cast in the presence of local magistrates, and we find a department in charge of the work.

Kin-Ngai-Bong was the artisan, Li-Shun-Jing was the local magistrate, and Shen-Khi-Lik was the Gien-Chi-Gwen-Gwan, not "acting" as was in 1680 Chung Shen Ching, but the regular officer. He was a Gwen or military mandarin. The board, however, which did the work was not the Tung Che Shi Tsien Zhe of 1680, the high provincial magistracy, but was the Tung-Ying-So. "Ying" signifies a battalion or division; "So" is an office, chamber or station which performs or forwards government business. It is also a station on the canal. Ying always implies an officialism which has to do with troops. In the title Ying-Ping-Han, conferred about B. C. 60 on Chao-Chung-Kwoh, and rendered the Marquis Organizer of Peace, this character Ying certainly refers to the military system which makes peace permanent. The French-drilled division of guards of to-day is the Shen-Ki Ying.

The force of the character "Tung" seems always to be that of high military designated or assigned duty in a capacity less than that of command in chief but greater than that of executing orders given in detail. One cannot say it always implies provincial authority. But if it does not, it implies connection with the Board of War. As good a translation of this part as can now be suggested is "Bureau of the select battalions," that is, selected soldiers for ordnance and artillery work. The "arsenal" is a good rendering.

The fact is now plain that the "petereroes in their buildings on the coast," spoken of by Duhalde, were a sort of gun which the Chinese knew well how to make as early as 1665, and called them Fulangkhi. These petereroes had been systematically classified, and those of the fifth size weighed rather less than a hundred and twenty pounds ($88 \times 1.33 = 117.33$).

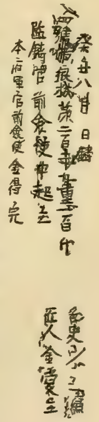
For the model or metallurgy of the Fulangkhi or light breech-loading swivel, the Chinamen were not indebted to the Jesuit fathers, but this sort of gun was older than any gun-founding for which they were responsible either as instructors or superintendents, and was of a different class from any recorded to have been done by them, all theirs being muzzle-loading work.

Duhalde complains that Verbiest was treated unfairly, that he was

chidden for delays, that the metal was stolen, and that attempts were made to disable the guns. One can hardly take these complaints seriously, they so betray the writer's ignorance of business. Of course the inspectors wanted to show that muzzle-loading guns were not as good as breech-loaders and tried to disable one of them. Of course the metal fell short. It always does, unless the melting is twice the weight of the finished article, and a wastage of ten per cent on a melting is not unusual. As late as the beginning of this century the natural deterioration and loss of metal in making the incrustation of the column Vendome caused the temporary disgrace and nearly caused the professional ruin of a French artillerist. Nothing but the discoveries of the great chemists of the time saved a very honest man from indictment as a swindler and fraud because of the natural deterioration and waste of bronze and brass in recasting.

THE GUN OF 1313.

The third gun of this Corean capture has a sturdiness of modeling which may indicate an earlier date of manufacture. The lack of the ratchet for the elevating pawl strengthens this conclusion. This gun bears a six-column inscription, the characters of which are evidently cut with a graver, and are of a shape said by a competent critic to be of ancient style.



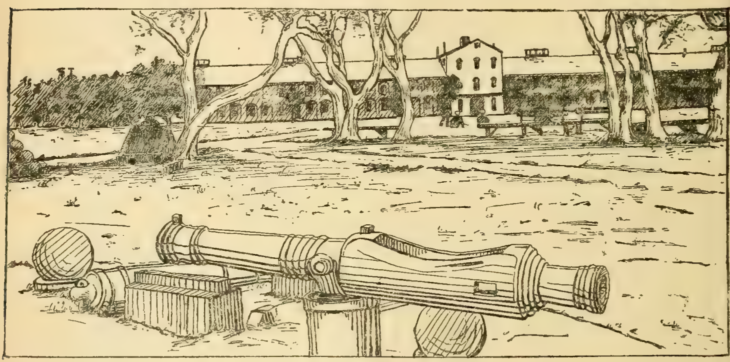
Two characters of the Hia Tse series (cycle of sixty) date it in the Kwei Chow, or fiftieth year of the cycle. It has no regnal title at the head of the date-column. Hence, although the absolute place of the date in some cycle is clear, the determination of the relative position of this year in any chronology requires a marshaling of evidence.

The inscription reads: (Col. 1) Kwei Chow, 8 month day, made cast. (Col. 2) 4 class Fulangkhi number two hundred twenty-nine, weight one hundred catties. (Col. 3) Make cast superintendent Tseng-Tsien Shi (Chief Assistant Privy Councillor) Shen Khi Lik. (Col. 4) Pen Fu Gwen Gwan (General of Ordnance superintending), Chief Assistant Privy Councillor Kin Tack Yuan. (Col. 5) District Magistrate Sung Si Lien. (Col. 6) Master Workman Kin Gai Lik.

The first notable thing about this inscription is that there is no regnal title at the head of the date-column,

and that the date-column is one character shorter than the next adjacent column on its left. If this were done for a reason and we knew why, it might assist in dating the piece.

At Fort Monroe there is a gun from this same Corean capture of this same size and shape which carries an incised inscription in six columns, the characters of which are of the same general style as those on the gun at Annapolis. The first, third, fifth and sixth columns contain respectively the same characters as the corresponding columns on the Annapolis piece; the second column differs only in the number of the piece, 194. The fourth is devoted to some sort of functionary, the "Pen Fu Gwen Gwan," and to the same "Kin Tack Yuan" as before, but his rank in the empire differs. When the Fort Monroe gun was made he was a Tseng Wan Hu. When the Annapolis gun was made he was a Tseng-Tsien She.



FORT MONROE GUN.

The characters Kwei Chow, which begin the date-column, are in the Fort Monroe gun, as in that at Annapolis, a character below the head of the next adjacent column on the left.

There can be no doubt that these two contemporaneous records of identical formulæ, which mention four different men in four different responsible positions, three of them, as the old English phrase goes, places of worship, two of them ranking as Assistants to the Privy Council, memorizes a time when there was an organized gun manufacture producing thirty-five guns or more a month. Kin Tack Yuan, one of the managing officers, was promoted during the month.

The fact that both guns lack the regnal title shows that it was omitted purposely. The fact that the date-columns are shortened by one character at the top shows an intent to fill them afterwards.

It will not be worth our while to search for this Kwei Chow year earlier than the crusade of St. Louis nor later than the epoch K'ang Hi. Within these limits the eighth month of a Kwei Chow year might fall about September in any of the years A. D. 1253, 1313, 1373, 1433, 1493, 1553, 1613, 1673.

The inference is unavoidable, however, from the structure of these date-columns, that while the same foundery was at work under the same superintendency casting at the rate of thirty-five small guns a month of successive numbers, melting two or three tons of brass each month, and about the beginning of the eighth month of the year, some event happened which rendered the engraver doubtful about the regnal title, and caused him to leave a blank in this part of the inscription, to be filled when the doubt was solved.

Such a doubt could only arise on an impending change of regnal title. If, therefore, we can find some Kwei Chow years after the institution of the Pen Fu office in which, in the eighth month, a change of regnal title was impending, we shall have an indication to assist us to the exact cycle of sixty to which these two guns belong.

An emperor of China is nameless during his reign. After his death his family confer a title by which he is inscribed in the ancestral temple and by which historians may speak of him. Usually this name is not one which has been associated with him in his lifetime. An emperor is spoken about in his lifetime by various titles, such as Son of Heaven, Autocrat, Dragon's Throne, and he refers to himself as The Solitary, or by some epithet deprecating divine visitation.

Every emperor, however, on ascending the throne, decrees the phrase by which the epoch of his reign shall be known till further orders, and determines whether this epoch shall begin at once or in the future.

Usually the new epoch begins on the next New Year's Day. This epochal phrase continues in use with the years numbered in series under it till a new epochal name is adopted. That may go in use at once or at a later day, usually New Year, and the years of the new epoch are numbered in series beginning again at one. Some rulers have had great versatility in these regnal titles, using three or four in some years, and averaging one a year for ten or fifteen years, as for example the Empress Wu-How. Others kept the same regnal

title Kang-Hi, or Kien Long, for sixty years. If, therefore, a change of regnal title took place in the last part of a Kwei Chow year, or at the beginning of the next year, while the Pen Fu office was active, it would be a pregnant indication.

In A. D. 894, the year succeeding a Kwei Chow year, the Emperor Chow Chao Jung changed his regnal title, King Teh, to Kien Ming.

In A. D. 953 an emperor died, and his successor proclaimed his regnal title as Hien Teh, to take effect on New Year's Day, 954.

In A. D. 1074, on New Year's Day, the Emperor Liao Tao Jung (a sort of side-show emperor of an intrusive house) changed his regnal title from Hien Yung to Ta Kang.

In A. D. 1314, on New Year's Day, the Emperor Jen Tsung of the Yuan dynasty changed his regnal title from Hwang King to Yen Yew.

No other change of regnal title was made in a Kwei Chow year, or a year next succeeding a Kwei Chow year, from A. D. 1314 till now.

Unless, then, it is absolutely incompatible with other indications, the second year Hwang King (A. D. 1313) is probably the Kwei Chow year in question.

To satisfy this or any other assumed date of manufacture four other things must concur. There must have been a Pen Fu department at the time, and in that department two officers of the rank of Tsien Shi and one of the rank of Wan-Hu. If these officers or the department did not exist in any of the Kwei Chow years, such years would be excluded from consideration.

The late Chinese Minister at Washington, Mr. Chang Yin Hoon, at request of Secretary Bayard translated the Fort Monroe inscription, and with a politeness characteristic of his nation declared to the Secretary that he was "grateful for being permitted to *share* in the pleasure of perusing the curious inscription." To his research is due the discovery of an ancient ordnance department and its organization. His communication could not be published without violating the customs of diplomacy and the rights of authorship, and yet a paper on this subject which did not accord to him the credit of the discovery would fail in honesty as much as it would in politeness or gratitude. To him, therefore, in consequence of this discovery, the following argument owes its fundamental fact, and so most of its force.

The great emperor of the Mongol dynasty, Kublai Khan, then employing the ruling title of Che Yuan, in the eleventh year of that part of his reign (A. D. 1274) established a department for the con-

trol of gunners. The siege of Siang Yang Fu, when he is said to have taken Western engineers into his service, was then pending.

Eleven years later (22d year of Che Yuan) he reorganized the department (A. D. 1284). At the head of it was a Ta-su-ko-shi. It had a Wan-Hu and a vice-Wan-Hu. Attached to it were two Privy Councillors, Shu-Mih-Yuan or Shu-Mih-Shi, and two assistants, Tsien Yuan or Tsien Shi.

Abbé Grosier in his "Description Générale de la Chine," Paris, 1795, relates that Kublai's armies under Sotou had in the year 1283 been repulsed in Cochin China by the "Mahommedan cannon" of the Annamese. Late in 1281 the Japanese expedition had been destroyed after lying off the shores of Japan for weeks unable to effect a landing. It is perhaps fairly doubtful whether the fleet carried guns, but Griffis, in the "Mikado's Empire," gives an engraving from a Japanese picture of the repulse of the Mongols which represents junks in the offing wreathed in cannon-smoke.

KUBLAI, FROM YULE'S MARCO POLO.

The title Pen Fu implies personal imperial relations and is very nearly equivalent to Ministry of the Household. Privy Councillors and Assessors of the Privy Council, as officials, indicate importance, and a Wan Hu, as a subordinate, also indicates this. A Wan Hu at this time must be taken as equivalent to the chief of a banner of Mongols.

Such a bureau so elaborately organized would not fall into decay in the six years which elapsed before the death of Kublai, nor in the twenty years from Kublai's death to Jen Tsung's accession.

Our Kwei Chow year of 1313 occurs at a period when every

criterion is satisfied. There is in the State a Pen Fu department with its two Assessors of the Privy Council, and Wan Hu as officials, and there was, near the close of the year, an impending change of regnal title which was a sufficient reason for leaving a blank for the two missing characters. One might well doubt if he was in the epoch called Hwang King or in that called Yen Yew, if the change had been determined on. To prepare and print the calendar for distribution on the first of the tenth month, two months' time for drawing every page, for cutting the blocks, for printing, binding and assorting for delivery many thousand copies, is not too much time, and this carries us back to the eighth month as a necessary time for determining the text of the new phrase.

Previous Kwei Chow years are already excluded by the lack of the bureau and its officers. Later years will not furnish the reason for a blank. But if they also lack the ordnance office of the Mongols, the date of 1313 will become certain.

Kublai, grandson of Zinghis, and First Emperor of Yuan Dynasty.

Before taking up the direct evidence on this point let us consider a little the state of China when the Mongols obtained and while they held and when they lost the throne.

For over two hundred years before the time of Kublai there had been two bitterly antagonistic emperors in China, and for the thousand years before, it was only at intervals that any ruler pretended to exercise more than a tax-taking jurisdiction over this vast territory. Some attempts at imperial legislation had been made. Some efforts, by establishing inspection circuits, had been had at uniformity of administration and regularity of justice. But China was not yet a nation such as England has been since the days of Edward III.; such as France became through the seismic politics of the Revolution, the Empire and the Restoration; such as Japan became on the restoration

of the Mikado; such as America is since the experience of the Civil War.

Zenghis had marched to its conquest early in the century, when it comprised two sovereignties, the Sung, which ruled south of the Yang Tsee Kiang, and the Kin, which ruled the northern provinces. The Kins were intrusive Tartars. The two kingdoms were normally at war from the policy of the Kins, and the boundary between them was defined rather by present prowess than by monuments or treaties respected by both sides. An attempt to introduce a militia system in the Sung empire at the close of the eleventh century had strained the sinews of loyalty and shaken the imperial throne. The Sungs encouraged the Mongol war upon the Kins for the sake of present rest.

As general for his uncles and for his own brother, Kublai, before he became emperor, had reduced the remote western and southern provinces of the Sung empire without more resistance than could be offered by the levies of local authorities, and without stimulating the Sung emperor to great warlike preparations.

The Mongols, bred for ages to a nomad and pastoral life, dwellers in tents, hunters and warriors, united by families into clans, tribes, hordes or banners, and into a confederacy of greater or less strength according to the ability of the leader, were always a migrating nation. They took what they needed and passed on. They enslaved their prisoners, and promoted their slaves by adoption. The national organization was merely military. The national revenue was plunder. Sharing the loot paid the soldier and his officer. They swept a country clean as they went through it. Kublai's military system and that of his generals was to enter a province, summon the towns, take possession of the provincial government, receive the attornment of the authorities, disband the local army, put a Mongol detachment with a Mongol leader in charge, and move on. The disbanded soldiery generally incorporated themselves with the moving army, because the Sung system had been to consider a soldier as a bandit hired on the side of lawful authority instead of arrayed against it.

Recalled from his southern expedition to assume the throne, Kublai left his general Pe-yen to practice the same policy, and himself led the northern army to the conquest of the province of Houquang. Siang Yang Fu was taken after a five years' siege, and subsequent operations gave Kublai control of the Yang-tsee above Nanking. The Sung emperor had left only the provinces of Che-Kiang,

Fokien and Kwang-tong, all on the sea-coast, all self-supporting, all populous, and all of them commercial and industrial as well as agricultural. Again Kublai attacked in detail, sending Peyen into Fokien and going himself to Che-Kiang. Six years more of war against three baby-emperors ended the struggle. But if, after the complete conquest of the Kins, it had taken twenty years to subdue the southern empire, where there was so little national spirit and no large mutual helpfulness, so that the invader could take it province by province as he would eat an artichoke, leaf by leaf—the simile is Caesar Borgia's—what could he have done against a China as united, as single in purpose, as patriotically devoted to its emperor as the Mongols were?

His imported Mongolian alloy was perhaps one or two per cent of the population, certainly not more. He could not breed a nation in many generations. He must educate one. He established a provincial system directly dependent on the central power at Peking. He united the north and the south by the greatest of engineering works of that and, till recently, perhaps of any day,—the great canal. He tried to secure public confidence by giving his administrative and judicial offices to natives of Chinese race, while he kept the purse and the sword in the hands of Tartars, or, in some few instances, of devoted foreigners. He was lavish in succoring popular distress. He adapted his methods to Chinese customs, and celebrated all the Chinese worships with a catholic or indifferent spirit quite paralleled by the policy of Henry of France when he thought "the good city of Paris was worth a mass."

The roads, the bridges, the system of post-houses and of scattered military posts a league or so apart along the highways and canals, doing the duty of messengers, signal men and rural police; the public granaries, which sold the tribute corn in times of dearth at moderate price; the slack-water navigation inaugurated or enlarged and maintained by Kublai, all kept in full view of the people and paid for by the public revenue, show his centralizing policy, his determination that in his conquest at least there should be no question who was the head of the State.

Artillery, for a hundred years after it was introduced into European war, was a special profession quite distinct from soldiery. The professional artillerist was gun and bullet founder, powder-maker and combatant. The profession first became truly military under Louis XIV., and it is only within a hundred years that artillery-drivers have

been enlisted men. Kublai, in the interests of his centralization, nationalized the profession as a branch of his household ministry.

Jen Tsung, when he came to the throne, resolved to open the career of native talent still wider. He ordered the Sung history to be compiled as a concession to Chinese glory, and entrusted the service to Chinese. He instituted more rigid examinations in the civil service, and removed from the lists many officials who could not pass the new ordeal. He appointed men of Chinese race to places of power as well as of responsibility. He found the centralized provincial policy of Kublai unpopular, and modified it in the interests of local authority. His successors still further relaxed the control of the capital. Yet in 1355, under Shunti, the last Yuan emperor, a preponderant Mongol officialism was one of the great complaints.

JEN TSUNG OR KWANG KING.

SHUNTI.

The Yuan dynasty from Kublai's reception of the southern kingdom in 1280 to the accession of Shunti in 1333, was generally satisfactory to China, and probably a model administration for the Orient.

Shortly before the accession of Shunti, earthquakes and floods

had devastated the northern provinces, and the provincial revenues of food and money had been exhausted. Vast sums were needed to repair the disasters, and policy required and necessity obliged local remissions of tribute from the impoverished. Before full succor could be brought, thousands of houseless, masterless peasants had taken to brigandage for a livelihood, and on the repetition of the disasters the number of husbandmen turned robbers yearly increased. They went south. To collect the tribute in the maritime provinces and in the interior, to bring it north and distribute it, needed all the forces of the empire administered by Tartar energy. There was war with Corea, and the imperial armies were disastrously defeated. The Kin Tartars had again got their breath and invaded China to play again for the lost kingdom. The Emperor began to meet this situation as a boy of thirteen. His ministers, his generals, his armies, his provincial system made head against revolt at home and invasion from abroad for thirty-five years. The general who finally dethroned him was a native Chinese, Chu Yuen Chang. He had been bred a priest, had enlisted under Kwoh Tsee Hing, a revolted chief, was promoted for merit, and married his patron's daughter. In 1355 Prince Kwoh died, and General Chu took the command of an army with the rest of his wife's inheritance. The unfrocked *bonze* took the side of order, and adopting Kublai's strategy, moved from province to province. He set up and made efficient the administration of each province, and gave the executive officers a sufficient rural police, thus localizing part of his army under competent command. He re-established the course of trade, restored interrupted communication by cara-

KWOH TSEE HING.

van and canal, and allowed the customary tribute to go forward to Peking. He claimed only to be duke of a province, a mere feudal chief, and to act only when the legal authority had been disturbed, and then only to restore it by appointing a new magistracy, which was always Chinese. Two upstarts prematurely announced themselves claimants of independent sovereignty. One of these, Chen Yeo Liang, took possession in 1363 of the narrow gorge at the corner of the three present provinces of Hupeh, Kiang-Si and Ngan Hwei, through which a third of the trade of China must pass,—the surplus and the imports of two-thirds of an hour of longitude and of about eight degrees of latitude—a defile controlling the water transportation west of longitude 116° and south of latitude 32°, and held it by a fleet on the Yang-tsee Kiang and Poyang Lake. The fleet was captured or destroyed in a series of naval engagements relentlessly prosecuted day after day till the ships were burned or sunk and the claimant drowned in the lake. The artist of the battle represents his wild-eyed head as the single object above the surface of a broad waste of waters to show the fulness of the victory. After this Chu refused to claim the Dragon Throne. The other claimant, Chang She Cheng, challenged in 1367 the authority of General Chu by proclaiming himself king of Wu, and was promptly crushed. In the rejoicing over this victory the soldiery demanded an end of subjection. For thirteen years they and they only kept the peace of the empire south of the Yang-tsee. No imperial army had aided or opposed them. What if Shunti were Emperor, he was a Tartar, and it was time that China should be for the Chinese. The yellow mantle was assumed and the dragon-flag displayed on New Year's day, 1368, and the revolted power of southern and western China marched on Peking. An advance up the canal converted much of the empire into the commissariat of the insurrection. A heavy flanking column moving through Honan captured the river and canal system from that province and from Shensi. Within four months the larder of Peking belonged to the insurgents. The Emperor held only the capital, its magazines, a few square miles around it, and the relics of his Tartar army. One last spring

END OF BATTLE OF POYANG LAKE.

at the throat of his adversary and at the fleet of supply-boats on the canal was defeated, and Shunti and his court retired to the north, leaving his capital to the victor. China had united against Yuan, and the Mongol had yielded. The Chinese say that the armies of Shunti were well supplied with artillery.

CHANG SHE CHENG.

With the brilliant men who had aided to establish the Ming dynasty, the Hung-Wu epoch had no difficulty in forming an efficient ministry and an able provincial administration. The Emperor trusted them more than had been customary for nearly a century, and devised a system which made the provinces almost independent principalities, owing to the Empire, after their magistrates were appointed, nothing but homage and tribute. The Emperor's family became powerful princes, with governments and independent revenues derived from the taxes of their government. He established his own court at Nan-King, and gave his fourth son, Fo, the northern subdivision, with the title of King of Yen. This prince, who inherited much of his father's genius for war, was sent into Tonquin with an army in 1401, and was defeated with great slaughter by the "fire-weapons" used by the enemy. In 1403 Prince Fo ascended the throne by the regnal title of Yung-lo. He employed cannon in his revolt against his nephew. His generals four years afterwards used fire-weapons to secure victory over the Tonquinese. The Ming historians who relate this say that these instruments were called Shen Khi (divine machinery) and that the Shen Khi Ying was organized by the Emperor to have charge of them. The Ming historian attributes to this war in Cochin China and to the Shen Khi brigade the introduction of firearms and war-rockets into China, and goes on to explain that they were kept a State secret for many years, and, although known to high authority and used in the armament of

forts, they were not allowed to be made away from the capital, or to be publicly seen until after the beginning of the sixteenth century, and were not generally introduced in the army before 1522.

Mr. Mayers, of the English legation, read before the North China Branch of the Royal Asiatic Society in 1869 a paper "On the Introduction and Use of Gunpowder and Firearms among the Chinese." This was published in the Society's Journal and also as a separate pamphlet. It may be consulted at the Boston Public Library, and also in the library of the Artillery School at Fort Monroe.

Mr. Mayers was unable to admit an earlier use of rockets or guns than that of 1403, in the reign Yung-lo. Dr. Edkins, of the London Mission, in a paper printed in U. S. Ordnance Notes No. 312, of July 6, 1883, reviews the ground and concludes in favor of a use of projectile artillery by the Sungs before 1280, but thinks the secret was lost under the Mongols.

Chu-Yuan-Chang first Emperor of the MING Dynasty. Dynastic Title Hung Wu.

In transmitting a Chinese print of Shunti, Mr. Wong writes, using the Chinese characters for the name, "Shunti was the Emperor whose armies were amply provided with guns."

The evidence above cited is ample to state these propositions as facts:

1. There was an ordnance and artillery department in China called Pen Fu, as part of the Ministry of the Household, as early as 1284.

2. As early as 1284 firearms were well known to the higher army officers, and just before that year had been successfully employed against Chinese armies.

3. This ordnance department continued as an active organization into the reign of Shunti, who fled in 1368 into Tartary.

4. In reorganizing the administration of China, on the decentralizing plan of the Mings, this department was not continued, probably for the reason that most if not all of the personnel had fled across the frontier with the dethroned emperor.

5. When artillery is next needed in the reign of Yung-lo, a new artillery and ordnance office is created under a new name, which keeps the manufacture of cannon quite secret till about 1522, or about the time the Portuguese arrive in China.

This state of facts, or of facts and high probabilities, exclude all Kwei Chow years from and after A. D. 1273 inclusive, for we have the flight of the Mongol Emperor and his personal ministry in 1368 and 1369, and the reorganization of the government of China at Nan-king and the establishment of a less dependent provincial system in 1368–9.


PRINCE FO AS KING OF YEN.

For some years there was no central ordnance or artillery department. When it reappeared it was by a different name. Curiously enough the revival is first mentioned in the revolting army of Prince Fo, King of Yen, just before he becomes Emperor. It was therefore first reorganized as part of his great northern establishment, and perhaps, indeed probably, was got together by collecting the workmen, the models and the traditions left behind by the Mongols. If so, a Shen Khi could probably have been found at Peking to organize a brigade of gunners, the sound of whose name expressed in other characters could well express the "divine machinery" then introduced.

The Ming provincial system, when administered by less energetic men than its founders, did not yield peace and order within or without the empire, and to its inefficiency may be attributed the disorganization which led to the substitution of the present dynasty.

Col. Favé, who completed the Emperor Napoleon III.'s elaborate treatise on Artillery, investigated this subject of early artillery with great care, and found saltpeter mentioned as early as 1240 in Arabic literature. It had then been long known in Egypt as Chinese snow. Before the end of another quarter of a century, directions had been given for purifying it and for combining it with alder or willow char-

coal and with sulphur, in proportions, fit for rockets, of six parts niter, one part sulphur and two parts charcoal. Crackers and serpents were also described. Before the end of the century the rocket was described by another Arab as the "arrow of Cathay." About the beginning of the next century (A. D. 1300) a breech-loading gun was described as an arrow-shooting "Mad-faa," and a drawing of it was given. The drawing was a mere diagram, about as good as Benton's in the U. S. Ordnance Manual, and was evidently made by a person who had seen the machine. The description as evidently was written by a man who was struggling with a subject imperfectly understood. It requires the breech-block to be tied in place by a raw-silk cord, and prescribes that the shaft of a spear shall be bored out for the barrel and recessed for the reception of the breech-block. The name Mad-faa is quite beyond any real etymology. Yet seemingly our study suggests an explanation.

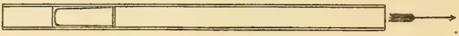
The sound "Pao" signified in Chinese at a very early period a machine for throwing stones. The same sound has been continued for the stone-throwing cannon, as for the stone-throwing catapult. The character which represents this sound has suffered these modifications as the generic idea has changed. Now it is written 炮 suggesting an envelope 包 of fire 火. The form which preceded this was 砲 suggesting a stone wrapped up. At a still earlier date it was written 礮 suggesting a stone striking a horse. Mr. Mayers brought this out clearly in his paper.

The elements of these characters receive no phonetic notice from the Chinaman, but they suggest ideas to him as he reads.

This archaic ideograph made known by Mr. Mayers fully explains the situation which gave Col. Favé's Arabic author his name, his accurate picture, his confusing description.

Three people at least were concerned in it—a Chinaman who made the drawing and described it in Chinese and wrote out the Chinese name, an Arab who put the questions about the drawing and wrote out the answers in Arabic in a connected form, and an interpreter

who had probably an imperfect knowledge of both languages. The Chinaman would have no conception that any one would want to give a phonetic value to the ideographic elements of the written character. The Arab would, from the structure of his Semitic language and alphabet, lack the conception of a character in which the elements were not phonetic. The interpreter would fail to make two minds come together or appreciate their degree of separation. The Arab, asking to have the name written for him, would see the successive elements marked down, and would learn that they were 石 *shih*, which he would understand to be the projectile, and 馬 *ma*, horse, 大 *ta*, great, 交 *pa*, strike, all forming the one word *pao*. Naturally he would combine these syllables phonetically in the natural Arabic manner and produce the word Maatpa or Madfaa.*



MADFAA, AFTER FAVÉ.

The very syllable that is redundant in a Chinese etymology betrays the Chinese source of the Arab's information, and the diagram of the machine shows the breech-loading system we are considering. The item about the silk cord will be considered later.

We have found this type of piece existing early in the fourteenth century and described by a name fairly traceable to a Chinese origin by a Western writer of the period. We are now prepared to believe the statements of Dr. Edkins, that Western cannon were used in

* Evidently the fractional character above taken as *ta* was so called by the Chinaman, although it is written in the derivative form 六 *luh* (six); and the form rendered *poa* (strike) was pronounced as in its primitive or radical form 八 *pa* (eight); the two in combination having the sense of nearness, contact, or striking.

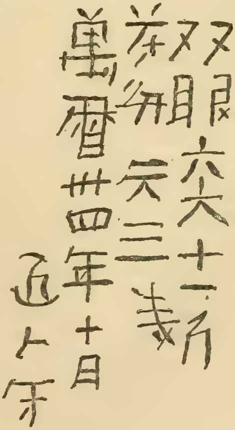
1234 at Tsai Chew, and that a "fire exciting hand gun," or, as Col. Favé calls it, a "furious firing spear," was known as early as 1259. This last was said to be made of a large thick bamboo, and to have had a projectile called by Favé a nest of seeds, and by Dr. Edkins thought to be an explosive bullet. The many fanciful names given to cannon in Europe which have finally settled into "cannon" (great reed) should prevent any surprise at the description of a gun-barrel as a bamboo. Marco Polo's statement that the Chinese used in war bamboos, the explosion of which could be heard for leagues, may lead us to imagine that some such word was employed in this sense in the thirteenth century.

To explain this statement about the "furious firing spear," Admiral Rodgers brought us another witness.

THE CHARLESTOWN GUN OF 1607.

There is at the Charlestown yard a curious bronze gun from the same Corean capture.

It is about eighteen inches long. It weighs some fourteen pounds. It is double-barreled. It has three reënforces on each barrel. Each reënforce has a vent, those of the left-hand barrel on top, those of the right on the right side. The barrels are modeled to represent stocks of bamboo, and reënforces to represent root-knots. It has a hollow cascabel and no trunnions. The cascabel is very much worn and grooved as if by a lashing of small stuff which had attached it to a shaft (the raw silk cord of the "madfaa"). It bears an inscription on the cascabel, of course much abraded, but still legible in most of its important parts. It was made in 1607.



It reads: (Col. 1) Double-sighted six shooter, weight eleven catties. (Col. 2 is nearly illegible, most probably it once read) Tcha Fu Shi San Chuen (the Tea Prefect San Shuen or of San Chuen). (Col. 3 is quite legible) Wan Lik thirty-fourth year, tenth month day. (Col. 4) master workman Chu.

Wan Lik was the regnal title from

Double barrel Magazine Gun Reign Wan-Lik, AD 1607. At Navy Yard Charlestown - Mass. Corean capture of Adm. Rogers.

CHARLESTOWN REPEATER.

1573 to 1620 of an emperor in whose reign the Japanese invaded Corea. History records that in this war, in 1593, a general's horse was killed by a cannon shot, and in 1598 a cannon shot was used as a signal. Griffis' "Mikado's Empire" states that a breech-loading cannon is still preserved in Japan as a relic of this invasion.

This curious early repeater fully illustrates the furious firing spear with its nest of seeds and its bamboo barrel of the Sung period, and we are no longer obliged to reject the evidence of the writers of the Sung, Kin and Yuan histories because we do not understand it.

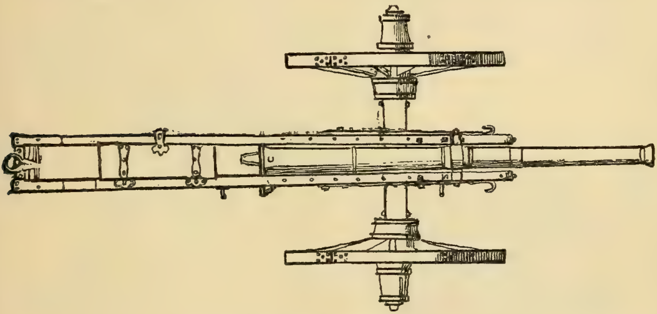
We have also discovered another thing, that some scion of the Shen Khi family of 1313 must have remained in China, because we find one of that name in 1665 at work manufacturing guns, and it is possible that the Shen Khi brigade may have been originally named for one of them before it got its literary form. This, however, is mere conjecture.

All these breech-loading guns were called by the founders by the special name Fulangkhi. Mr. Mayers cites a Chinese author who wrote about 1517 concerning the Portuguese. He spoke of their guns by this name, and said that this name was rightly a name of a country and not of cannon. Mr. Mayers conjectured that the Portuguese had been called Franks by some person, and the name had been transferred to the guns. No evidence is found anywhere that the Portuguese were ever called Fulangkhi's, and Mr. Mayers apparently did not know that the term continued to be an official term for guns as late as 1680. The Portuguese guns are said to have been of iron, jacketed with wood and strongly hooped. This hardly was the model from which to make a brass gun like these of this museum.

Again, these Chinese Fulangkhi differ from the pedreros of Europe by having hollow instead of solid cascabels, which seems to imply a different course of development. Undoubtedly Fulangkhi might mean French. As undoubtedly, in some of the treaty ports to-day, Fulang is taken for France, and for foreign generally. Probably when the set of characters were devised to designate the machine it

was believed to have come from abroad with some barbarian invader from the West. When an Arab calls the rocket the Arrow of Cathay, and the breech-loading cannon Mad-faa, he goes far to admit an early use of gunpowder in China wars; and when the Chinaman speaks of Western and of Mahommedan cannon and of Fulangkhi, he goes far towards calling the instrument an imported article. We are not called upon to settle the place of origin of this class of weapon exactly, but only to date one gun.

Our date for that has been fixed at A. D. 1313, and the only catalogued gun older than this is the Fulangkhi of Fort Monroe, made in the same month.



Burgundian Gun, Plan after Favé.

It is pretty clear from some old bills and accounts that gunpowder artillery was used in European war before 1300. It is not disputed that the hand-grenade was used in China as early as 1233. We have no drawings of any gun except the "madfaa" earlier than the fifteenth century.

Some ancient guns are preserved in Europe and Asia, and the Royal Artillery Institute have published a series of papers by Lieut. Brackenbury which describe and illustrate some of the most curious of them. They date as follows:

1318. Bombard at Amberg, Bavaria.
1379. Wooden-cased gun at Venice.
14th century. Tower guns, London.
1423. The Michelettes at St. Michel.
1430. La Dritte Geriete of Ghent.

1460. Mons Meg at Edinburgh.

1464. Turkish guns at Constantinople.

1475. Captured in 1476 and 1477. Guns of Charles of Burgundy at Morat and Neustadt.

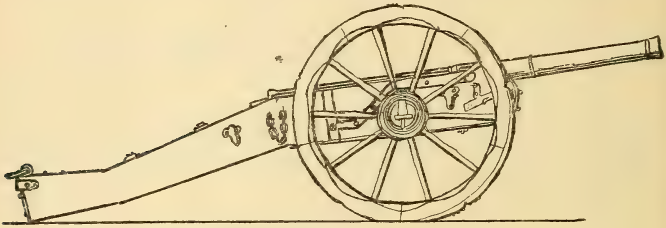
1478. A gun of Louis XI. in the Paris Museum of Artillery (structure not described.)

1535–1539. Two sakers at Woolwich.

1542. The Mary Rose guns at Woolwich. All by Arcano de Arcani.

1546. Czar Pooschka at Moscow.

16th century. Malik y Mydan at Benares.



BURGUNDIAN GUN AT NEUSTADT, AFTER FAVÉ.

Besides these is the double-barreled draconcillo cast at Liege in 1503, now at Madrid, and the Bartemy de Pins gun of 1490 at Paris, and the banded gun in the Tower, about 1545.

Probably the above list contains more than half of all the guns now extant made before 1500. There may be fifty guns now extant made in the sixteenth century.

De Saulcy declared that the most important improvement in field artillery was the introduction of trunnions and the flask or bracket trail system of mounting, and that the origin of the improvement is unknown.

One gun of Charles of Burgundy, a cast-iron piece, may fairly be said to have this improvement. The Bartemy gun was doubtless so mounted.

Both these guns, however, were preceded in Europe by the swivel system, illustrated by the Cortes guns at Annapolis and Washington, which are undoubtedly older than 1474, when Isabella acceded to the throne of Castile. By her marriage contract it was provided,

in 1469, that after her access the arms of Aragon should always be associated with those of Castile and Leon, and, as these guns were marked with Castile and Leon only, this fact dates them earlier than 1474.

The pedigree of the Bartemy gun and of most European artillery is traced to the wooden-stocked guns of Burgundy by the adjustment of their trunnions lower than the axis of the piece, while the independent origin of the Cortes swivel, of the Madrid draconcillo and of the Fulangkhi's appears by the emplacement of their trunnions abreast of their bores.

Without attempting to account for the origin of the name Fulangkhi, it is worth remembering that the earliest illustration we have of the landing of St. Louis at Damietta represents his army as provided with cannon.

DE MOLAY.

TAMARLANE.

THE HISTORICAL PERSPECTIVE OF THE FULANGKHI OF 1313.

The war of Cortes in Mexico is a remote American event. It began twenty-six years after the first voyage of Columbus, nearly three and three-quarters centuries ago. The oldest Fulangkhi was then as old as the Cortes swivel was in the reign of Queen Anne. The year of Hwang King, called Kwei Chow, was at a notable period in the history of the world.

The Crusades were over. The modern period had begun. Robert Bruce was King of Scotland, and in another year he would win the independency of his kingdom at Bannockburn and strike down before both armies Sir Henry Bohun, the English champion, break-

ing his axe in the blow. Edward II. was then King of England, and English people were still discussing the recent fall and execution of Gaveston. Henry VII. of Luxemburg was Emperor, Dante was in his prime, and Petrarch was a schoolboy. Clement V. was Pope, and the Papacy was settled at Avignon under the protection of Philip the Fair. The order of the Temple had just been dissolved. De Molay was to mount the scaffold in a year, and to summon Philip in judgment at a year and a day of essoin, and Philip would be laid in his coffin in two years' time. The Polish mortgage to

SEAL OF ROBERT BRUCE — OBVERSE.

Brandenburg, never redeemed, had just laid the foundation of Prussian power. Russia then paid tribute to the posterity of Zenghis. The Arabic caliphates of Cordova and Grenada survived in Spain, and the last sigh of the Moor would not breathe farewell to the Alhambra for a century and a half, leaving its name to the overhanging hill. The grandsons of Rudolph held petty principalities in Germany, but the Hapsburgs were not a reigning family. Charles of Anjou ruled Hungary. Venice was sovereign over most of the Greek Empire, and Athens was an independent principality of a French duke. Tamarlane would be born in a quarter of a century,

but a hundred and forty years would elapse before the cannon of Mahommed II. should batter the walls of Constantinople.

Pope Sylvester had invented a mechanical clock, but a child born in this year 1313 would be over sixty years old before any French church would have one on its tower. It was two centuries before Europe knew of printing by movable types. Paper had been invented, was made in Spain, but France and Germany would not make it for a year, nor England for a century. Coal was only in use in the districts where it could be quarried. The use of water-

SEAL OF ROBERT BRUCE.— REVERSE.

power was confined to the blowing engine called the *trompe*, and to driving the wipers of small trip-hammers. Road-making was a lost art. Wheel-carriages were unknown or of the rudest sort, and transportation in Europe per ton per mile was paid at the rate of thirty cents of our money. The impossibility of an internal commerce made local dearths and famines severe and frequent. No postal service existed, no common carriers of freight or passengers. Floors were strewn with rushes and walls hung with carpets. Sugar was a confection, and two centuries would elapse before it would be a food. No forks were used at table. Every guest brought his own

knife. Many European nations would not arrive at the accomplishment of making soap for centuries.

Of the things quite unknown in those days, but quite usual to-day, were alpaca, coca, coffee, cacao, and chocolate, cochineal, jalap, logwood, maize, manila or sisal hemp, Peruvian bark and the cinchona and quinine alkaloids, potatoes and yams, tea, tobacco and tapioca. Among those quite rare were cotton cloth and indigo. Canned meats and vegetables were quite unknown, and more than three-fourths of all the food was heavily salted or smoked, often both. It was before the days of the whale fishery. Street lamps were unknown, and houses imperfectly lighted. There was no window-glass, almost no drainage, and chimneys were very poor.

To reduce the commonest and plainest people of to-day to the supplies of the luxurious of 1313 would be to deprive them of many of the necessaries of life.

What shall we say of the metallurgic skill, of the mechanical advances which had been made, as shown by the gun itself? Drills, files, gravers, modeling in sand, coring, dry distillation, winning of sulphur from the volcano and of niter from the earth, a selection among charcoals for special properties, all must have been contrived, learned and practised before this gun was made.

Why, with this great advance thus early, has the Chinese development of firearms been so slow and apparently retrograde?

First. The national policy did not permit the use of firearms to the people, or to any but a limited part of the army.

Second. The soldier till quite recently was required to purchase the materials of his powder and to make it himself. We learn from Barrow that as late as 1793 a formula was in use which was deficient in saltpeter and called for an excess of sulphur and of charcoal. Moreover, the purification of the niter was defective. Granulation has not been thought important.

Third. Mechanical improvements have been neglected, and no attempt made to get a more modern type of gun than the match-lock. Small-arms of inconvenient weight have been preferred, and the cartridge was never thought desirable.

Fourth. Candidates for commissions or promotion have been deterred from attempting improvement by the rigid formalism which required adherence to the ways of the past at the age of acquisition, as a condition of success in the schools.

Fifth. A preference of provincial authorities for local economy

rather than for national efficiency and power. This again is but another name for the unsympathetic selfishness which Kublai meant to correct.

Sixth. The peaceful relations of China with the rest of the world other than Asiatic nations unskilled in mechanics have made the situation of comparatively small consequence till recently.

The tributary relation of Corea to China accounts for the presence of these weapons in that kingdom.

It is, however, strange that an American naval force should have captured in one day five guns, all of them older than the time when white men first occupied the great Mississippi River system, the cotton and corn field of the world.

Two of these guns were far older than the time when America was first brought to the knowledge of Europe; a third, the Charlestown repeater, was made in the very year in which Virginia was planted; a fourth, in the year when arbitrary government was threatened to Massachusetts by the appointment of the Carr-Maverick commissioners; and the fifth, in the year the first royal government was established by the charter of New Hampshire, and the only feudal government ever set up in the old United States territory was established in the Massachusetts province of Maine. It is strange that this force from the New World should have brought them from that Far Cathay, whose fame was the cause of the expedition of Columbus, and it is stranger still that men should be living to-day, still in active service, who can say they have heard the hostile roar and have been exposed to the peril of shot projected from the oldest extant pieces of artillery of the world.

PROFESSIONAL NOTES.

THE SCREW FERRY-BOAT.

By E. W. Woolsey, Superintendent Hoboken Ferry Company.

As early as 1805, a screw steamboat, constructed by John Stevens, made a run as a ferry-boat between Hoboken and the city of New York. This boat was about 24 feet in length, built upon the Whitehall pattern, and was propelled by twin-screws at the stern. The engines of the boat are now in the Stevens Institute of Technology at Hoboken.

The steam ferry-boat from its introduction in 1812 has always been of the sidewheel type, although as early as about 1850 the construction of a screw-boat for ferry service was contemplated, and indeed plans for such a vessel prepared. In 1867 the subject was again agitated, but the project abandoned under the belief entertained that such a mode of propulsion was impracticable, chiefly because of the fear that no screw could be made to stand against the ice that packed in the ferry-slips.

The gradual increase in traffic between the cities in the port produced a problem as to how best to meet the subject and provide adequate facilities. No more landing-places in the city of New York could be obtained than were already held by the various companies, and without additional landings a greater number of boats could not be run with any advantage to the public; larger carrying capacity must therefore be provided.

In 1887, with this problem before them, the Hoboken Ferry Company commenced the design for a screw ferry-boat. Without any previous experience upon which to build, nor yet any vessel of approximate character to consult, the Bergen was designed, built, and in March, 1889, was placed on duty where she has since performed a most satisfactory service both as to speed, economy, facility of handling and increased capacity, which is 29.8 per cent more than a sidewheel ferry-boat of equal length and breadth. The following table will compare the Bergen with one of the sidewheel boats of the Hoboken ferries:

Table.

Hull.	Bergen, Steel.	Moonachie, Wood.
Length L. W. L., feet	200	200.
Beam " "	32.16	32.
Beam over guards	62	62.
Draught to base line	8.83	7.5.
Space available for passengers	4330 aft	3335 aft.
" " " teams	3448 aft	3380 "
Number of seats for passengers	296	236.
Engine—type	T. Ex. Propeller	Low press. beam.
Size	18½″ x 27″ and 42″ x 24″	44″ x 10′
Steam pressure	160 lbs.	30 lbs.
Average HP in regular service	665	450 estimated.
Speed measured mile	14.6	
Average speed in regular service	13	11 estimated.

By comparison with the largest sidewheel boat in the service, the Bergen will consume 9 per cent less coal to produce the same results. The perform-

ance of the screw ferry-boat in ice is such as to place it far in advance of any other type of boat required to make a head-on landing. The screws (submerged two feet below the surface of the water) have never suffered breakage by contact with ice, nor has the speed been materially affected in passing through large fields.

The hardest ice service, however, is that which is packed in the slip and held fast by the bridge pontoon in front and the racks on either side. While under these conditions there are times when the sidewheel boat cannot force her way to the bridge, but the screw-boat makes her way without difficulty, the forward screw clearing the pathway for the entrance of the hull, and at no time, even under the worst conditions, has the use of a gang-plank been necessary for the landing of passengers or teams.

The peculiar model, in which are employed a full, flaring upper body, a very fine under-water body, with a full water-line and a sharp V-shaped midship section, and the peculiar cutting away of the ends to bring the rudder and screws within the perpendicular of the stems, is responsible for the stability of the vessel, the ease of entrance and clearance, and of her valuable ice qualities.

The fact of the screws being upon one shaft, and the forward one pulling when under headway and meeting a most solid resistance when reversed, renders the stopping qualities exceptionally good, and experience has demonstrated that the screw-boat can kill her headway and come to a dead stop in about half the resistance required by a sidewheel boat. The steering qualities are all that can be desired, the helm being answered very quickly and with great steadiness.

Following the Bergen, and after she had proved her value by actual service, the N. Y. L. E. and W. R. R. Co. constructed the John G. McCullough, following the same general principles though differing in detail. After this the P. R. R. Co. produced the Cincinnati, and about the same time the Bremen and Hamburg were commenced by the Hoboken Ferry Company. All of these are now in successful operation.

The writer has the honor of having been intimately associated with the designing and construction of the Bergen, Bremen, and Hamburg, as well as now having charge of their operation, and while making no attempt at a scientific consideration of the subject, has endeavored to submit something of the history of the screw ferry-boat and the results thus far obtained.

It has not been found that the screw-boat is more economical than the beam-engine boat as to fuel, manning or repairs, but its commercial value in carrying capacity, facility of loading and unloading, and ease of motion, added to the perfection of handling to which I have alluded, renders the type one which must inevitably be adopted by all ferry corporations who have to face the constantly increasing tide of travel to and from the great metropolis.

THE FIRST-CLASS CRUISER EDGAR.

(From *London Engineering.*)

We have completed our description of the cruiser Edgar and of her machinery, and have given the general results of speed trials; but these are worthy of more careful consideration, both on account of their interest and also of their rarity. For it must be noticed that, while private firms can systematically carry out elaborate speed trials of all their ships, or test the performance as to consumption of steam, etc., of all their engines, and find this to pay; while also thousands of pounds and months of time can be given to try torpedoes, nets, etc.; while we can afford to send torpedo-boats full tilt at floating fortresses; yet we are, we believe, correct in saying that not one thorough speed trial has ever yet been carried out in the navy, and we are perfectly sure that the consumption of steam of not one engine of a ship of war is known. It may be, of course, that the trials of the Greyhound in 1873 finally settled all questions

regarding the resistance of ships, and that we now need nothing but model experiments, though we should be sorry to state that this is so; but they certainly settled nothing about the engines. However, no doubt the efforts of private firms will in time supply us with facts sufficient to complete, so far as such a thing is possible, our knowledge of the steam engine; and meantime the highly educated young engineer officers, on whose training the Admiralty spend a fair amount of money, can go on as usual settling the exact dimensions of a stoker's blue collar, or seeing that he spills no drops of oil to mar the purity of the first lieutenant's clean decks.

We give in tabular form the results of seven trials on the measured mile at Stokes Bay, and for comparison the two contractors' trials for acceptance of the machinery at Plymouth. In order to show the results clearly, they are plotted graphically on a diagram accompanying this article, the horizontal scale being of knots, and the vertical the corresponding indicated horse-power, the curve *ABCEFG* is then drawn through the spots obtained. Before, however, the curve can be drawn, a correction must be made, because, as will be seen from Table I., the trial is marred by a change of draught. The trials were to be at or about 10, 12, 14, 16, 18 knots and full speed, and the 10, 12, and 14 knots trials being made on one day, the draught was for some reason or other altered before continuing; then a trial at about 13 knots was made, in order, we presume, to bring the two sets of results into comparison before proceeding with the 16 knots, etc. This change of draught is unfortunate, but we can only endeavor to allow for it by estimating its probable effect. We calculate thus:

	ft.	in.
Mean draught on 24th	23	2½
" " " 27th	23	9
Change of draught, or 2.27 per cent.	0	6½

This change will mean an increase of about 4½ per cent on the wetted surface, and hence also on the indicated horse-power.

We add then 4½ per cent to the 10, 12, and 14 knots indicated horse-powers; and we also apply a similar correction to the two trials at Plymouth, adding 4 per cent to the full-power trial indicated horse-power, and subtracting 1 per cent from the natural draught trial indicated horse-power. Doing this we obtain the numbers in the second column of Table II., and plotting these in the diagram, obtain in order the points *KGLFEDCBA*; we should then draw a fair curve through these points, except *K* and *L*, but it will be found that we cannot bring the point *D* into a fair curve, so we are obliged to leave this point out and conclude that probably some inaccuracy occurred in that particular result. There will also be noticed a slight flatness at *B*, appearing to indicate that the indicated horse-power given for this speed is somewhat large; but still, the want of fairness is small; and remembering that *C* is for the same day and conditions as *E*, *F*, and *G*, we should not attempt to draw a curve including *D*, but decide that the results for *D* are in some way inaccurate as just stated.

In order to separate, if possible, the engine efficiency or a part of it, we next draw the curve of indicated thrust. In column 4, Table II., we have the speeds of the screw calculated; and, dividing the energy exerted per minute by the engine by these, we obtain column 5 of indicated thrusts. These values are plotted in the diagram at *kglfedcb* and *a*, and the curve of indicated thrust for the progressive trials should pass through *gfedcba*. But we now find that not only is *d* out of the fair as we should expect, but also the slight want of fairness at *B* is on this curve accentuated, so that *b* lies above the straight line joining *a* and *c*. This shows us that the results for *B* and *A* are not consistent with those at *CEF* and *G*; either *B* and *b* are too high or *A* and *a* are too low, or both. Thus altogether it appears that we cannot attach much value to the lower results, and it is therefore of no use to attempt to determine the constant engine friction, by prolonging the thrust curve to cut the vertical axis, even supposing the lowest speed determined, viz., 9.647 knots, had not been too great to use for this purpose.

TABLE I.—*Details of Trials of H. M. S. Edgar.*

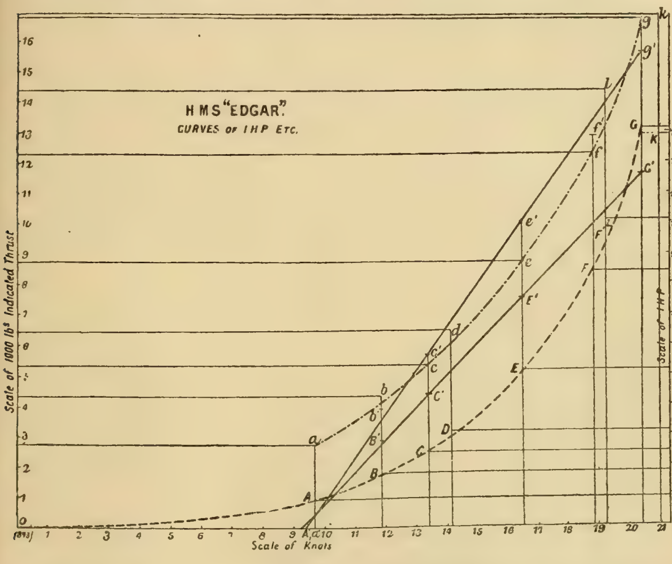
	Trials off Plymouth.		Progressive Trials on Measured Mile at Stokes Bay.						
	Natural Draught.	Full Power.	10 Knots.	12 Knots.	13 Knots.	14 Knots.	16 Knots.	18 Knots.	Full Speed.
	Nov. 4, 1891.	Nov. 19, 1891.	Nov. 19, 1891.	Nov. 24, 1891.	Nov. 27, 1891.	Nov. 24, 1891.	Nov. 27, 1891.	Nov. 27, 1891.	Nov. 27, 1891.
Draught of water { Forward	23 ft. 3 in.	22 ft. 9 in.	22 ft. 8 in.	22 ft. 8 in.	23 ft. 0 in.	22 ft. 8 in.	23 ft. 0 in.	23 ft. 0 in.	23 ft. 0 in.
Draught of water { Aft	24 ft. 6 in.	23 ft. 10 in.	23 ft. 9 in.	23 ft. 9 in.	24 ft. 6 in.	23 ft. 9 in.	24 ft. 6 in.	24 ft. 6 in.	24 ft. 6 in.
Revolutions	99.2	104.5	45.3	55.9	63.1	65.9	79.3	92.8	106.2
Pitch of screws	23 ft. 4 in.	24 ft. 4 in.	24 ft. 4 in.	24 ft. 4 in.	24 ft. 4 in.	24 ft. 4 in.	24 ft. 4 in.	24 ft. 4 in.	24 ft. 4 in.
Speed	19.25	20.97	9.647	11.87	13.4	14.015	16.512	18.836	20.488
Indicated horse-power	10,179	12,463	880	1690	2464	2997	5102	8401	13,101

TABLE II.—*Analysis of Results of Trials at Progressive Speed of H. M. S. Edgar.*

Speed. Knots.	Indicated Horse-Power.	Revolutions.	Speed of Screw.	Indicated Thrust.	Speed of Ship.	Slip per cent.	Log Speed.	Difference.	Log Indicated Horse-Power.	Difference.	Power of Speed which Indicated Horse-Power varies as.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
			ft. per min.	lb.	ft. per min.						
20.97	12,961	104.5	2542.8	16,821	2124.96	16.4					
20.488	13,101	106.2	2584.2	16,730	2076.117	19.7	1.3114996		4.1173044		
19.25	10,077	99.2	2314.7*	14,366	1950.67	15.7		.0365109		.1929734	5.3
18.836	8,401	92.8	2258.1	12,277	1908.715	15.5	1.2749887		3.9243310		
								.0571890		.2165905	3.78
16.512	5,102	79.3	1929.6	8725.4	1673.216	13.3	1.2177997		3.7077405		
14.015	3,132	65.9	1603.6	6445.2	1420.187	11.4		.0906949		.3160998	3.48
13.4	2,464	63.1	1535.4	5296.8	1357.87	11.5	1.1271048		3.3916407		
								.0526541		.1446500	2.74
11.87	1,766	55.9	1360.2	4284.5	1202.83	11.5	1.0744507		3.2469907		
								.0900584		.2832029	3.14
9.647	920	45.3	1102.3	2754.2	977.563	11.3	.9843923		2.9637878		

* Pitch 23 feet 4 inches for this trial.

One point, however, is very clearly shown by the true, *i. e.* upper part of the curve, viz., the loss of speed due to the drag of the bottom in the comparatively shallow water of the measured mile. It will be noticed that the points *Kk* lie below the fair curves, while *Ll* for the natural draught trials lie above. The latter, however, need not be considered, since there was in that case no special need for great accuracy in the determination of the speed. But on the full-power trial the speed was determined with considerable accuracy; and it will be found that, drawing through *K* a parallel to the base, this cuts the indicated horse-power curve just half a knot to the left of *K*. We conclude then that at Stokes Bay, with the same indicated horse-power and draught as at Plymouth, the speed obtained would have been half a knot less; this half knot then must be the loss due to the bottom drag.



The third set of points on the diagram $A'B'C'E'F'$ is plotted by drawing ordinates representing log indicated horse-power, the base line being taken such a distance below OA that the spot corresponding to the lowest speed may fall on A', or, which is the same thing, the ordinates from the base line in the figure represent the difference of the log of each indicated horse-power from the log of the smallest one, viz. 920. If the relation between indicated horse-power and speed were

$$\text{Log I.H.P.} = a + bV,$$

where a and b are constants, then the spots would all lie on a straight line. In the figure a straight line is drawn through C' and G' which passes very near to E' and B'; but F' lies considerably below it, a result we should hardly have expected, since neither in the curve of indicated horse-power nor of thrust is

there any sign that the results of this trial are low. Of course we should not expect B' or A' to come in fairly, but we see that B' does very nearly; so that the probability is that the unfairness at B and b is due to a too small value of the indicated horse-power at A.

A law which is sometimes assumed to represent the facts very closely is

$$\text{Log}\,\frac{\text{I.H.P.}}{\text{revolutions}} = a + bV;$$

or, as we term it,

$$\text{Log (indicated thrust)} = a + bV.$$

To test the correctness of this law the points $a'b'c'e'f'g'$ are plotted in a similar way to $A'B'$, etc., a' and A' coinciding to start with. But there being room on the diagram the scale is double that of $A'B'$, etc., which accounts for the greater slope of abc. So far as can be seen this law is no closer than the preceding, the only difference perceptible being that the line $a'c'$ lies closer to or more evenly between a' and b', thus tending to divide the inaccuracy between the two trials; f' again is below, and e' practically on the line.

The remaining columns in Table II. show: The slip per cent, where it will be seen the 14-knot trial again is anomalous; and also the very great increase of slip at the maximum power shows that the ship is reaching the limit of speed for her size and form; and the calculation of the power of the speed according to which the indicated horse-power varies between the different speeds; the results in column 12 are obtained by dividing those of column 11 by the corresponding figures in column 9. The 14-knot trial is omitted, and the numbers found point to the unfairness at B, and also, seeing the sudden increase from 3.78 to 5.3, to a possible understatement of the indicated horse-power at 18.836 knots.

THE FISKE ELECTRIC POSITION-FINDER.

(From *Iron Age*.)

Some time since Lieut. Bradley A. Fiske, U. S. N., designed a range-finder consisting of two telescopes placed at the ends of a measured base and connected in such a way with a galvanometer, placed in any convenient location, that the range in yards of the object on which the telescopes were directed was read directly from the deflection of the needle. The two telescopes were connected by a telephone, so that there was no difficulty in directing both telescopes at the same object. By adding another galvanometer to the instrument, says *Engineering*, from which we quote, Lieutenant Fiske finds he can so arrange matters that the reading of the instrument gives at sight the angle which a line joining the object aimed at and the center of the telescope base-line makes with the base line, so that by this addition his range-finder is converted into a direct-reading position-finder, giving at once both the range of the object in yards and its direction. If, therefore, the guns are placed near the center of the base line, they can be directed on any desired object without it being necessary that that object should be visible from the battery. In the former finder the two telescopes were mounted on trunnions over a circular plate, around part of the periphery of which was placed a platinum wire, forming two arms of a Wheatstone bridge. The telescope carried a sliding contact which determined the proportion of platinum wire going to each arm of the bridge.

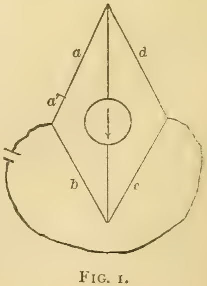
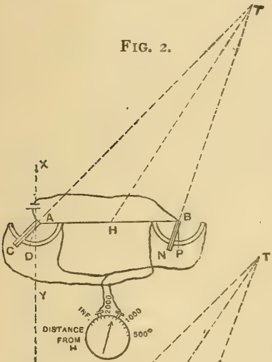


FIG. 1.

If the telescopes were aligned, say on a star, so that their lines of sight were practically parallel, each was displaced through an equal arc from its central position, and the sliding contacts divided each wire similarly, so that no current flowed through a galvanometer connected with the bridge in the usual way. If, however, the two telescopes were aligned on an object, say 3000 yards away, these axes were no longer parallel, the sliding contacts were displaced unequal amounts, and a current flowed through the galvanometer. This is shown diagrammatically in Fig. 1, where a and b represent one platinum wire, and c and d that at the other telescope. As long as $ac = bd$ no current will pass through the galvanometer; but if one contact is moved to the point a' the galvanometer is immediately deflected. Perhaps this is shown still more clearly in Fig. 2, where AB represents the base line at the ends of which the two telescopes are placed, represented by C and N. The arcs shown below the telescopes correspond to the arms ab, dc of the Wheatstone bridge in Fig. 1. If the telescope C occupies the position AD it will be parallel to BN, and the two arcs will be divided up similarly, so that no current will pass through the galvanometer. If, however, both telescopes are sighted on T, CA will no longer be parallel to BN, and the two arcs are no longer similarly divided by the sliding contact. Hence a current will pass through the galvanometer, the deflection of which will depend primarily on the difference between the angles through which the two telescopes are deflected from their new position on the angle ATB. By rearranging the connections, however, as shown in Fig. 3, the deflection of the galvanometer will now depend on the sum of the angles through which the telescopes are moved from the zero position. This rearrangement is practically the same thing as if the arc CD was given a half-turn round the axis XY. Then, in order that no current shall pass through the galvanometer, the telescope C must be in the position D, making an equal angle with the base to that made by telescope N. In such a case it is obvious that the line joining the object with H would make an angle of 90° with the base AB. But as the two telescopes have been moved in opposite directions from their normal positions, which is 90° with the base, the bearing of the object as seen through one telescope will be $90 + \theta$, and through the other $90 - \theta$, θ standing for the angle through which the telescopes are moved. The mean of these is, of course, 90°, or equal to the bearing of the object from H, the center of the base. Under the above conditions no current will pass through the galvanometer, which is accordingly graduated so that the point of no deflection is lettered 90°.

FIG. 2.



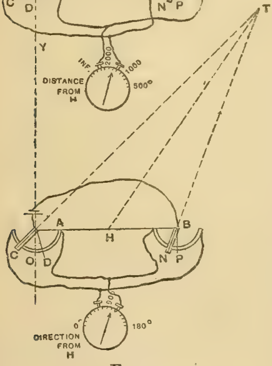


FIG. 3.

If, instead of the telescope C being at D', as supposed, both instruments are sighted in T, as shown, the arms of the Wheatstone bridge will no longer balance and a current will flow through the galvanometer, deflecting its needle.

This deflection will, as before, depend upon the sum of the angles through which the telescopes have been moved, of course taking regard to sign, and hence as before will denote the mean bearing of the object from the ends of the base, or, what is practically the same thing, the bearing as seen from H, the center of this base.

By using two galvanometers and coupling one up as just described, and the other as for the range-finder, it is obvious that both direction and range of any object can be obtained at the same time. This arrangement is shown in Fig. 4. The two galvanometers are connected to the telescope as explained, and the guns are situated midway between the telescopes, so as to occupy the center of the base line.

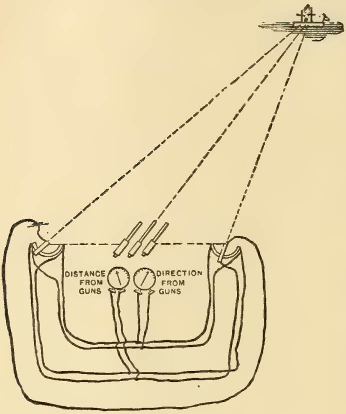


FIG. 4.

In practice it is found advisable to make the resistance of the direction galvanometer and its connections quite high, so as to interfere as little as possible with the indications of the range galvanometer, and in this way both direction and distance are obtained simultaneously and continuously. It will be seen that the telescope stations can be placed at any convenient points, and by suitable precautions could be rendered perfectly indistinguishable to an enemy at a little distance away. The guns, too, could be quite out of sight of the enemy, particularly if adapted to high-angle fire, so that by the adoption of this system the great desideratum of modern defensive tactics—viz., to give the enemy no salient point on which to fire—is fulfilled. In certain cases it may not be convenient to have the guns arranged midway between the telescope stations, as shown in Fig. 4, but the range and direction can easily be reduced to any other point once their values for a given point are known. It will be noticed that this new position-finder entirely avoids some of the inconveniences met with in using depression range-indicators and position-finders. The indications of the instrument are unaffected by changes, sometimes quite sudden, in the refraction of the atmosphere or by the rise and fall of tides. Furthermore, it is not necessary to sight at any particular part of the vessel, such as the water-line, which may be shrouded in smoke, but any one part of the ship, such as the top of a mast or funnel, or, indeed, any point that can be seen simultaneously from both telescope stations, is all that is necessary for the successful use of the finder. This new position-finder appears to us particularly suitable for coast defense, and we hope our War Office authorities may take the matter up and thoroughly test the value of the instrument for this purpose.

ENGINE AND HELM CONTROL.

The present means of communicating directions from the captain or the officers stationed on a steamer's bridge to the engineer or machinist on watch in the engine room, or to the quartermaster at the wheel, are either mechanical or

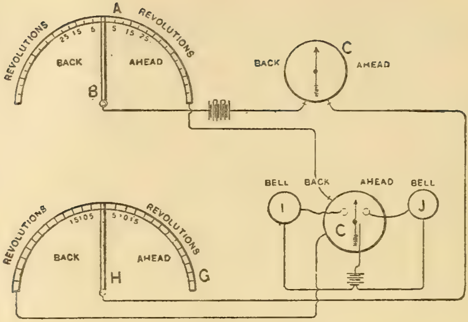
electrical. The mechanical devices are, as a general thing, cumbrous in construction, difficult to operate and quite easily put out of order. The electrical devices are almost always complicated and in addition are very expensive. There is, and has been for years past, urgent need for a simple apparatus by means of which the person directing the movements of a vessel may not only communicate his orders instantly, but may know with certainty that they are understood and are being executed. This is of the greatest importance aboard war-ships, where the outcome of a conflict in favor of one side or the other may be dependent upon the rapidity and facility with which the opposing vessels are handled.

It is a serious objection to the existing modes of intercommunication that they do not enable an order to be transmitted with sufficient accuracy. Thus it is quite possible to send a signal to put the helm, for example, to "port" or to "hard a-port" and to instruct the engineer to "back" or "go ahead" fast or slow, or to stop. But there is no reason why much more specific instructions should not be sent, by means of which the vessel may be more accurately controlled. This point receives particular emphasis when several vessels are cruising together or indulging in tactical manœuvres. In this case almost continuous engine speed-changes are required to enable the vessels to maintain proper distance. Furthermore, in action, with casualties constantly occurring, it is exceedingly important for the commanding officer to know that his orders have been clearly understood and implicitly obeyed. The more automatically this intelligence can be conveyed the greater the immunity from error and the more rapidity possible.

After a great deal of practical experience afloat and much study of the subject, Lieut. Bradley A. Fiske, United States Navy, has recently developed a signaling system of great ingenuity, which brings the guns of the battery, the helm and the engine room much more completely under the control of a single person than has ever hitherto been accomplished. The system includes numerous arrangements of apparatus, which are quite well represented in the accompanying diagrams. The system as here given is for use for controlling the engine or the helm. In a somewhat modified form it could be readily adapted for transmitting from the observer to the gun-captain the distance the target is from the firing position, as determined by the clever range-finders that have been adopted by our navy department and that of several of the foreign powers.

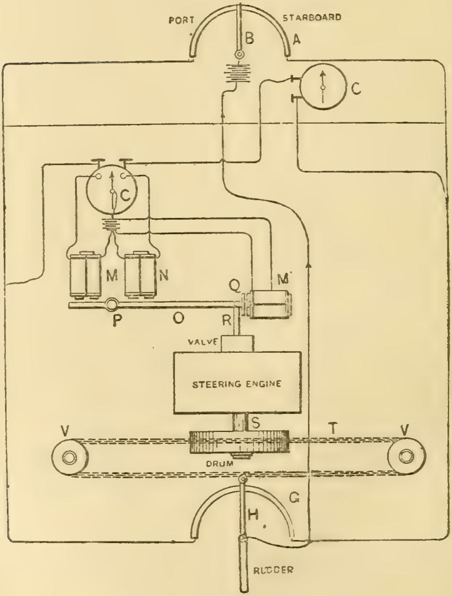
Referring first to Fig. 1. Here are shown two arcs of conducting material, over which move two pivoted arms, B and H. The arcs are graduated on each side of their central points to indicate the revolutions made by the propeller of the vessel. The arcs and arms are connected in series with two indicating instruments; one arc and one indicating instrument being located, for example, on the vessel's bridge or in the conning tower, the other one in the engine room. In connection with the needle of the instrument of the engine-room indicator are arranged two local circuits, each containing a bell or other suitable alarm, which circuits are respectively closed as the needle moves to its stops in one direction or the other.

If the apparatus be arranged as indicated in the diagram, the arms being at the middle points of their arcs, and it be desired to send a signal to the engineer to "go ahead," the arm B should be moved to the right. By this means the resistance in the circuit is diminished, causing a deflection of the needles of the two indicators in the same direction. The engineer then not only sees the needle of his indicator move, but also hears a bell sound. And as this bell may be of different tone, for example, from the one included in the other local circuit, he has both visible and audible notice of the order. Meanwhile, the person sending the order notes by the deflection of his indicating instrument that it has been transmitted.



A
REVOLUTIONS
REVOLUTIONS
BACK
AHEAD
B
C
BACK
AHEAD
BELL
BACK
AHEAD
BELL
I
C
J
REVOLUTIONS
REVOLUTIONS
BACK
AHEAD
H
G

FIG. 1.



PORT
STARBOARD
B
A
C
C
M
N
M'
Q
P
O
R
VALVE
STEERING ENGINE
S
V
T
V
DRUM
G
H
RUDDER

FIG. 2.

Now suppose further that it be desired to have the vessel go ahead at slow speed. The speed of the vessel for a given number of revolutions being approximately known, the person sending the signal moves the arm *B*, for example, to the mark 15 on the arc *A*. The results already referred to will then occur. The engine-room bell will, however, continue ringing and the needles of the indexes will remain deflected until the engineer re-establishes the balance of the circuit. This he does by moving the arm *H* on his arc *G* to the right to the number 15. He will thus obviously have thrown into the circuit a resistance equal in amount to that by which the total resistance in the circuit had been diminished, thus restoring the normal condition. The needles of the indexes will then return to their normal position, the alarm will cease sounding, and the person sending the signals will be apprised that his order has been exactly complied with. By this device an exceedingly accurate and certain mode of regulating the speed of the ship is at all times available, and confusion resulting from hastily given and but partially understood orders is done away with.

In order to directly control the helm so that the rudder may be adjusted at any exact and desired angle, and also to cause knowledge that the order transmitted has been correctly executed, the apparatus shown in Fig. 2 was devised. It is an automatic means of controlling the helm directly and without the intervention of any one but the person sending the signal.

In this case, as in the one already described, there are two arcs, *A* and *G*, over which move pivoted arms *H* and *B*. These arcs are connected in Wheatstone bridge circuit with a battery and with two indicating instruments, one of which is located at the sending station and the other one near the steering engine which controls the helm. No particular form of steering engine is required; any one of the standard patterns already in use will do. For example, take one that operates a drum, *S*, around which pass chains that are shackled to the tiller *H*, when the engine turns in one direction the tiller moves one way, and when it turns in the opposite direction the tiller moves the other way. The arm *H* on the arc *G* may be the tiller itself or an arm actuated by the tiller.

The two local circuits, which are closed by the movement of the needle of the indicator *C*, in one direction or the other, include electro-magnets, *M* and *N*, which operate a pivoted armature that in its turn moves the reversing valve of the engine. The magnet *M* is connected in circuit to the battery which controls the two local circuits, and serves to center the valve, when the parts are in normal position, as indicated in the diagrams. Now, when is is desired to put the helm in one direction or the other, the person stationed at the arc *A* simply moves the arm *B* in the direction in which it is desired to adjust the helm and also to the desired extent. This immediately disturbs the balance in the circuit, and the fact, as before explained, is shown on the indicator *C′* near him, while the needle on the distant indicator closes one of the local circuits, energizes one of the electro-magnets *M* or *N*, which in turn, attracting the pivoted armature *O*, moves the valve of the steering engine so as to cause it to move the tiller, and hence the rudder, in the desired direction. As soon as the rudder or the tiller *H* moves over its arc to an extent sufficient to re-establish the balance in the circuit, the parts return to their normal position, when the electro-magnet centers the armature and stops the engine. The operation, obviously, is thus entirely automatic, and the ship is steered merely by the movement of the arm *B*.

THE HARVEY PATENTS.

Some details of interest are given in the patents granted lately to H. A. Harvey of Orange, N. J., on the manufacture of armor-plate and guns. The specifications are accompanied by drawings showing the furnace in which the

operation is carried out. The future must tell whether Mr. Harvey can accomplish regularly and uniformly what he has undoubtedly succeeded in doing in isolated cases. Mr. Harvey's cementation process is described as follows:

The armor-plate having been formed of the desired size and shape from a comparatively low steel, such as Bessemer steel or open-hearth steel containing, say, 0.10 per cent to 0.35 per cent of carbon, is laid, preferably flatwise, upon a bed of finely powdered dry clay or sand, deposited upon the bottom of a fire-brick cell or compartment erected within the heating chamber of a suitable furnace. The plate may be so imbedded that its upper surface is in the same plane with the upper surface of those portions of the bed of clay or sand which adjoin the sides and ends of the plate, or the plate may, if desired, be allowed to project to a greater or less distance above the surface of the clay or sand. In either case the treating compartment is then partially filled up with granular carbonaceous material, which, having been rammed down upon the plate, is covered with a stratum of sand, upon which there is laid a covering of heavy fire-bricks. The furnace is then raised to an intense heat, which is kept up for such a period of time as may be required for the absorption by the metal adjoining the upper surface of the plate of, say, an additional 1 per cent (more or less) of carbon, or, in other words, the quantity of carbon, in addition to that originally present, which may be necessary to enable the said metal to acquire the capacity of hardening to the desired degree. The temperature of the heating chamber outside of the treating compartment is brought up to a height equal to or above that required to melt cast iron, and is kept up for a greater or less length of time, according to the depth of the stratum of steel which it is intended to charge with an excess of carbon. This period, however, will, of course, vary according to the efficiency of the furnace.

The degrees of efficiency possessed by furnaces can only be satisfactorily ascertained by actual trial. When ascertained, the reproduction of given results merely requires the re-establishment of the conditions as to time and temperature under which said results have been previously observed to be obtained. This involves merely the maintenance of the furnace at a heat sufficient to melt cast iron for the period which by previous observation has been ascertained to be the period required for adding to the tenacity of the steel and for the supercarburization of the plate to the prescribed extent and depth. For example, a plate, say 10½ inches in thickness, composed of a comparatively low steel, containing, say, 0.35 per cent of carbon, may be charged with additional quantities of carbon, gradually varying in amount from, say, 0.10 per cent at a depth 3 inches beneath the surface of the exposed side of the plate to 1 per cent at the surface thereof, by a continuance of the treatment for a period of, say, 120 hours after the furnace has been raised to the required temperature.

The statement that the heat at which the furnace is maintained is sufficient to melt cast iron is to be regarded as approximate merely. The more intense the heat the better, and while it will, of course, be understood that the longer the treatment is continued the greater will be the depth to which the carbon penetrates beneath the surface against which the carbonaceous material is packed, it is also to be remarked that the penetration of the carbon is greatly facilitated by the continuous firm compression of the carbonaceous material against the plate. As a general rule, the thicker the armor-plate the greater will be the permissible depth of supercarburization. A 10½-inch plate and a depth of supercarburization of 3 inches are herein referred to merely for the purpose of illustration.

After the conclusion of the carburizing treatment the plate is taken out of the furnace, and without removal of the carbonaceous material from its surface is allowed to cool down to the proper temperature for chilling. During the cooling operation the carbonaceous material protects the hot supercarburized

surface from the air, and thus prevents the formation of scale, which, if present, would interfere with the subsequent hardening of the metal beneath it. The carbonaceous material, however, may without injurious consequences be temporarily removed from and quickly replaced upon small portions of the supercarburized surface for the purpose of exposing them for observation. When it is seen that the supercarburized surface is so far cooled down as to have a dull cherry-red color, the carbonaceous material is quickly removed, and the plate is then chilled by being sprayed with torrents of cold fluid or by being submerged and kept in motion until cold in a large body of cooling fluid —as, for example, a more or less rapidly running stream or river of fresh water or a tidal current of salt water. The exercise of this precaution insures the subsequent uniform hardening of the supercarburized surface of the plate.

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DEUTSCHE HEERESZEITUNG.

Nos. 10 and 11. On the firing manual. French cavalry manœuvres of 1891.

No. 12. Moltke's field-plan, 1866. Reorganization of the English artillery. Organization of the military tricycle service in France.

In consequence of the report of a commission it has been determined to assign wheelmen to staffs and to bodies of troops, without organizing a special corps. The wheelmen are taken from the reserves and kept ready during peace. In war each corps headquarters will have 8, each divisional staff headquarters 4, each brigade 2, each infantry regiment 4 wheelmen, making about 4000 necessary during war. During peace about 2 wheelmen to each regiment are needed. On July 1st of each year a general meeting of applicants for this service will be held. One of the requirements for those assigned to staffs is to be able to make 56 miles in less than 6 hours, and for other posts 31 miles in less than 4 hours.

No. 13. Moltke's field-plan, 1866. Competitive firing between artillery and infantry in Italy.

This competitive target-match took place in the ranges at Cecina. From a battery of six 9-cm. guns 24 rounds were fired in 4 minutes with shrapnel (176 balls) against a battery target at 1600 meters distance. The 6 field-piece targets stood 10 meters apart, the ammunition wagons 15 meters behind; the positions of officers and men of the battery were also indicated by targets. The result of the firing was that 4 officers, 36 men, 6 guns and 3 limbers were hit. And as each man had received on an average 4 hits and each field-piece 8 hits, it amounted to total destruction of the battery. Eight volleys were then fired in 4 minutes by an infantry company of 191 files at the same target, same range. The result was that 8 men, 1 field-piece and 2 limbers were hit with an average of 1 hit each. The ratio of these hits to those of the artillery fire was approximately zero.

No. 14. Moltke's field-plan, 1866 (concluded). Russian artillery drills.

No. 15. The German navy and the Reichstag. The French army, 1891.

No. 16. Nautical retrospect. Observations on naval tactics.

Nos. 17, 18, 19. Observations on naval tactics (continued).

No. 20. Moltke's military works. New method of exploding spar torpedoes in France. Launch of the Grafton. Speed of torpedo-boats.

The following interesting data on the speed of torpedo-boats of less than 1000 tonnage are furnished by Mr. Yarrow:

Great Britain: Speedy, 21.5 knots; torpedo-boat No. 80, 23 knots. France: d'Iberville, 21.5 knots; torpedo-boats Coureur, Veloce, and Grondeur, 23.5 knots. Germany: Division-boats Nos. 5 and 6, 22 knots; torpedo-boats Nos. 65 to 74, 24 knots; Nos. 76 to 80, 25 knots; Nos. 75 and 81 to 96, 26 knots. Italy: Tripoli, 23 knots; torpedo-boats of Aquila class, 25 knots. Russia: boats of Adler class, 26.5 knots. Austria: boats of Comet and Trabant class, 20.5 knots; boats of Falke class, 22.4 knots. United States: Cushing, 22.5 knots. Argentine Republic: six 130-feet Yarrow boats, 22.5 knots. Chili: Lynch and Condell, 21 knots. China: Schichau boats, 24 knots. Denmark: two boats, 22.1 knots. Spain: Destructor, 21 knots; torpedo-boats of Rayo class, 24 and 25 knots.

Fortifications in Roumania.

No. 21. Naval appropriations. Observations on naval tactics (continued), IV. Rams.

No. 22. Frederick, Napoleon, Moltke, old and new tactics. New French infantry equipments. Reorganization of the Russian navy.

The distribution of the Russian fleet will be as follows: Of the 36 ships of the first class, 28 are assigned to the Baltic, 8 to the Black Sea; of the 48 ships of the second class, 38 to the Baltic, 8 to the Black Sea; of the 88 ships of the third class, 49 to the Baltic, 27 to the Black Sea. 7 ships are assigned to the Caspian Sea, and 5 to Vladivostok; of the 20 ships of the fourth class, 17 are assigned to the Baltic, 3 to the Black Sea. The fleet personnel consists of 2 high-admirals, 11 admirals, 34 vice-admirals, 29 rear-admirals, 285 staff officers and 337 subalterns. The sailors and marines number 30,500.

No. 23. Observations on naval tactics (continued), V. Torpedoes, coast defense and sea-going torpedo-boats. Improvements in the harbor of Tunis.

No. 24. Studies on science of war. Austrian transportable observation tower. Accident with melinite shell.

Nos. 26 and 27. Bicycle corps in Spanish army. Strength of Chinese army. Launch of the Italian cruiser Minerva. The Russian fleet.

No. 28. Russian regulations for field breastworks. The superiority of the Italian rifle. Ship-building in France (1892 to 1895).

Nos. 29 and 30. The fortified camp in Sicily. Observations on naval tactics (continued), VI. Surprises and protection against torpedo-boats. Telephone during French field-manœuvres.

Nos. 31 and 32. Observations in naval tactics (conclusion). Influence of the repeating rifle and smokeless powder on employment of cavalry. The military carrier-pigeon routes in Europe.

No. 35. Smokeless powder for Swiss artillery. Experiments in France. On the visibility and audibility of the discharge with French smokeless powder.

Rifle.—The smoke of the first shot from a rifle is scarcely visible when the bore is dry; visible at 600 meters when the bore is oiled. The smoke of the second shot is sometimes visible up to 200 meters. With the third shot and beyond no smoke is visible. With volley firing, even the most rapid, the visi-

bility does not increase. At night the flash at discharge is not visible beyond 150 meters. The report is sharper than in the old models. A single report is audible at 200 meters, a volley up to 2500 meters.

Field-piece.—Smoke scarcely visible in daytime, dissipated in 4 to 5 seconds. With a volley the smoke as seen from the side is thicker, but never sufficiently thick to hide the pieces and artillerists. No smoke is visible when the battery fires from behind cover and when three or four meters below and behind the earthwork. When the piece is exposed at a height of 3 meters the flash is visible at 4000 meters. No sign of flash, however, when the piece is placed 6 meters behind an earthwork 6 meters high. At night the flash of discharge appears about twice as great as with the old powder. Not any appreciable difference in the report.

MILITÄR WOCHENBLATT.

FEBRUARY 6, 1892. Review of the latest military inventions. The Canadian Pacific Railroad and its military importance to England. Rapid-fire guns for the French navy.

FEBRUARY 10. Review of the latest military inventions. Snow breastworks. Comparison between the new Swiss rifle and the Vetterli gun.

FEBRUARY 13. The historical development of the idea of universal peace. The German navy and the Reichstag. Changes in organization of Austrian artillery.

FEBRUARY 17 and 20. A contribution on the history of the French rifle M. 1886. Fortifications of the Gotthard, Switzerland.

FEBRUARY 24 and 27. The field-piece of the future. Two vital questions for the field artillery.

MARCH 2 and 9. Two vital questions for the field artillery (concluded). The Russian navy.

MARCH 16. A French proposition on infantry attack within the effective zone of small-arm fire. Rapid-fire guns in France. The grounding of the Victoria.

MARCH 26. Proof-firing with guns made of Swedish Bofors steel. The new Italian magazine rifle.

MARCH 30. The field-artillery question. Russian cavalry against artillery.

APRIL 23. English rapid-fire and machine guns. Launch of the French auxiliary cruiser Ville de la Civtat.

MAY 7. Cordite. H. G. D.

JOURNAL OF THE U. S. CAVALRY ASSOCIATION.

MARCH, 1892. The Union cavalry. The shock action of cavalry. Veterinary science for cavalry officers. Organization of cavalry scouts. A Confederate cavalry officer's reminiscences. Mounted infantry. Saddling. Letters on cavalry. Professional notes.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

MARCH, 1892. On the motion of elongated projectiles. Field-artillery fire. Succession list of the master-gunners of England. Steel

as applied to armor. Translation: The employment of plunging fire in the field.

APRIL. The operations in Virginia, 1861–65. Field-artillery fire. Succession list of the master-gunners of England, Part II (conclusion). Quick-firing guns in harbor defense. Translations: Registering pressure-gauge applicable to ordnance; Observation ladder for field artillery.

ELECTRICAL REVIEW.

MARCH 5, 1892. The American high-speed engine (illustrated). The transmission of power with special reference to the Frankfort plant.

MARCH 12. Electric lighting of buoys in New York harbor.

. . . In consideration of the fact that the buoys in Gedney's Channel are at the present time the only ones in the world lighted by electricity, a few words in relation to the means adopted to accomplish this result may prove of interest. The channel marked by these buoys is 1000 feet wide and about 6000 feet long, the inner or shore end being about 2¾ statute or 2½ nautical miles northeast from the point of Sandy Hook.

Two lines of heavy-armored three-conductor cables, manufactured by the Bishop Gutta Percha Company, are laid from the Hook Beacon to junction boxes, one on either side of the channel, and situated near the inner buoy on their respective sides. Spliced to these main cables, inside the junction boxes, are three separate single-conductor cables of lighter make, connecting the three buoys on either side of the channel, which are located about 2000 feet apart, with the main line. One of these single-conductor cables is spliced at the lower end of each buoy with the cable running up to the lamp, this wire being laid in a deep slot in the side of the buoy, and covered and protected by a strip of wood fitting closely over it and let in flush with the outer surface.

The buoys themselves are about 50 feet long and are made of a species of juniper wood found in the Dismal Swamp of Virginia, this timber being selected on account of its buoyancy and straightness of growth. They average from 10 to 12 inches in diameter at the top and bottom, and 15½ inches at the largest section, and are shackled at the bottom to a cast-iron sinker weighing 4500 pounds.

The protecting cage, in which the incandescent lamp is set, is composed of flat iron ribs, riveted to two iron bands encircling the spar, with a third ring at the top of the cage which serves as a handle. The upper part of the ribs and the top ring are turned so as to present the edge to the lamp, thus securing greater strength and obscuring light as little as possible.

The lantern itself, which fits securely inside this cage, consists of a circular base and stout framework of brass, having curved panes of thick glass in the sides and segmented panes at the top. It is so constructed that it can be lifted bodily out of the cage, thereby bringing away everything liable to need repair or other attention. Three short legs attached to the bottom ring fit into holes in brass ears riveted to the ribs, and the lantern is secured in place by two hinged screw-clamps, which are also secured to the ribs.

The lamp is rated at 100 candle-power, and the carbon is extra heavy and has three loops in the center, designed to give a distribution of the light as uniform as possible. One terminal wire of the lamp is connected to the bars of the lantern, and the other is carried through an opening having an insulated bushing and connected with the core of the cable. One of the armor wires of the cable is soldered to a rib of the cage to insure a complete circuit through the core of the cable, the lamp and the lantern and frame to the cable armor.

Since the service has been inaugurated, several improvements in minor details which experience has shown to be of value have been made, and to-day the entire working of the plant is as near perfection as it can be brought, considering the difficulties to be contended with. The original heavy lantern has been changed for a lighter one, and straight glass has been substituted for the curved panes first used, so that they can be more readily replaced if broken. The lamp is also so adjusted as to enable it to be taken out without removing the entire frame, if necessary, although the lantern can still be lifted out as formerly, if desired.

The color of the lights has also been changed, or rather they have been differently located, those on the starboard side of incoming vessels being now all red and those on the port side all white, instead of alternating as they were originally.

As an instance of the hard usage to which the buoys and lamps are sometimes subjected, and the excellence of the service rendered under those conditions, it is only necessary to mention that during the severe storm of January last the ice surrounding the lamps was as thick as a good-sized barrel, and the weight of this ice, combined with the heavy sea, was sufficient to keep the buoys for the greater part of the time completely under water. In spite of this, and regardless of the mass of ice surrounding them, the lamps continued to burn brightly and without injury, and, as often as they could manage to get their heads above water, were plainly visible from the shore of Sandy Hook, a distance of nearly three miles.

After passing Fire Island Light, the first objective point of incoming steamers is the Sandy Hook Lightship, which is situated eight miles from the Point of Sandy Hook and about five miles from the entrance of Gedney's Channel. This entrance is marked by two buoys, one of which is a "nun" and the other a whistling buoy, both being placed here as a means of extra precaution in case one should break loose or be displaced in any manner.

From this point the course is west-northwest one-quarter west for a mile and a half through Gedney's Channel, and to a point from which an alignment can be obtained with the Point Comfort and Waackaack Beacons on the Jersey shore. From here the course is west by south through the main channel for a distance of 3½ miles, which brings you inside the Hook and in line with the South Beacon and Sandy Hook Light. A short run northwest by west one-quarter west from here and the Conover and Chapel Hill Beacons come into line, and by keeping them directly astern a straight course can be laid to a point just below the Narrows, from whence it is plain sailing through the upper bay and into the North River.

MARCH 26. The Mount Carmel air-ship. The telephone during French army manœuvres, 1891.

COLLIERY ENGINEER.

BULLETIN AMERICAN IRON AND STEEL ASSOCIATION.

TEKNISK TIDSSKRIFT, 1892, Vols. 1, 2, 3.

MÉMOIRES, SOCIÉTÉ DES INGÉNIEURS CIVILS, February, 1892.

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY, January, 1892.

NORSK TIDSSKRIFT FOR SOVAESEN.

TENTH ANNUAL SERIES, VOL. 4. Prize essay. Routes to China. Yachting. The Nicaragua canal. Short weather review, summer and fall of 1891.

VOL. 5. Prize essay. On the bursting of guns during the past ten years. Yacht measurements. Torpedo-gunboats. Flying machine. The Russian navy. The battle-ship Jauréguiberry.

RIVISTA MARITTIMA.

FEBRUARY, 1892. The naval war-game, by A. Colombo (concluded). The German merchant marine, by S. Raineri (continued). Naval architecture, by G. Rota. Naval schools abroad and in Italy, by Dante Parenti (continued). Vocabulary of powders and explosives, by F. Salvati (continued).

MARCH. Observations concerning auto-mobile torpedoes, by G. Astuto. The German merchant marine, by S. Raineri (continued). Naval schools abroad and in Italy, by Dante Parenti (continued). Electricity on board war-vessels of the United States. Vocabulary of powders and explosives, by S. Salvati (continued).

APRIL. Notes on nautical astronomy, by P. Cattolica. The German merchant marine, by S. Raineri (continued). Letter on the expedition against Tripoli of Philip II. of Spain. Naval schools abroad and in Italy, by Dante Parenti (continued). Vocabulary of powders and explosives, by F. Salvati (continued).

RIVISTA DI ARTIGLIERIA E GENIO.

JANUARY, 1892. The Naples aqueduct. The exact solution of the ballistic problem by means of square of resistance, by F. Mola, lieutenant of artillery. Note on lightning conductors. The prospectograph of Fiorini.

FEBRUARY. The Naples aqueduct (concluded). The Swiss fortifications. On organization and instruction of regiments of the engineer corps. Firing drills of the field battery, by L. N. Winderling, captain of artillery.

MARCH. Actual fortifications. Brief consideration on siege batteries. Old and modern powders.

THE LONDON ENGINEER.

OCTOBER 2, 1891. The Royal Arsenal, Woolwich (illustrated). Marine engines of the U. S. Cruiser No. 6 (illustrated).

OCTOBER 9. 150-ton steam traveling crane. Woolwich Arsenal (illustrated). The Snyder dynamite projectile. Willey's boat-lowering gear (illustrated).

OCTOBER 16. On a thermo-electric method of studying condensation (illustrated). Engineers for the Naval Reserve. Triple-expansion marine engine (illustrated). Experiments with compound armor. Bursting of a Krupp gun.

OCTOBER 23. Machine riveting of ships' hulls. Greaves smoke-preventing furnace.

OCTOBER 30. The navy of the United States, No. 1. Electric railways.

NOVEMBER 6. Armor-plate trials at Shoeburyness (illustrated). Nickel-steel armor trials in France and America. Air-pumps. Cruiser No. 6, U. S. navy.

JANUARY 29, 1892. New quick-fire guns for the French navy. The Sims-Edison electric torpedo.

FEBRUARY 5. Probable influence of quick-fire guns on naval tactics.

On Friday, January 30th, Admiral Long read a paper in the theatre of the United Service Institution, on the "Influence of Quick-Fire Guns on Naval Tactics and on Construction." It would be impossible in a short summary to do justice to a paper which dealt with actual tactics and took up supposed courses followed by hostile fleets. For this our readers must consult the proceedings of the United Service Institution when published. It is, however, desirable to notice the general scope and treatment of this important question.

The lecturer began by quoting from *Modern Naval Artillery*, the work brought out last year in connection with the Elswick exhibits, the paragraphs describing the power of quick-fire guns in defeating torpedo-boat attacks. A comparison is made between a ship using three ordinary and three quick-fire guns, and it is pointed out that not only do the latter guns discharge six times as many rounds as the former, but they also have a much better opportunity of striking the enemy, because she moves comparatively little each successive round. About twelve shots a minute is considered the highest practical speed on service, although some guns fire up to fifteen rounds per minute. With cordite or other smokeless powder, the lecturer suggested that a torpedo-boat attempting to get through the zone of fire by daylight was engaged in a forlorn hope. In actions between ship and ship it seems probable that a vessel might be put out of action in half an hour by quick-fire without armor-piercing guns coming into play. This opinion is held not only by the writer of *Modern Naval Artillery*, but also by Mr. White, the director of naval construction.

The change brought about by the introduction of quick fire is made apparent when it is remembered that in 1880 the ram was looked to as the weapon of paramount value. Then the torpedo rose into rivalry with it, until now the combination of quick fire and smokeless powder seems to put the gun into the important place which it held in the days of Nelson. The bearing of this on tactics is obvious. Admiral Bourgois and others have pointed out the advantages to be derived by a vessel attacking with her side presented at 45 degrees to the direction of the enemy's fire, at and beyond which angle projectiles would not bite but glance off. The lecturer then followed the probable movements of fleets attacking in certain lines of order, and discussed how far one ship can render support to another.

The question of side armor naturally suggests itself here. Admiral Long, like many naval officers, has "a soft corner" for a belt carried up to the platform of the guns, so as, at all events, to protect their racers, and hence their power of working. He, however, did not desire to push this question far, as he felt that the relative advantages of each system must be worked out by naval architects. The unprotected condition of a cruiser against quick fire was dwelt upon, and it was pointed out that, as the 6-in. gun was likely to be the heaviest employing quick fire, there seemed to be a special advantage in using armor on heavy ships of the thickness called for to resist this gun. This we might, by the way, point out can hardly be taken lower than 12-in., even allowing for range and some indirectness of impact; in fact, a vessel carrying thicker armor than the Thunderer is needed, and with steel or compound plates instead of iron.

A very interesting point was raised in the now imperfectly protected and

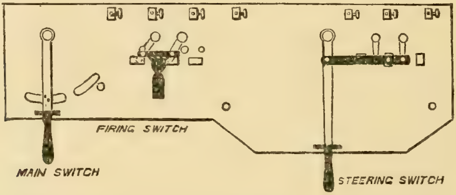
conspicuous position of the conning tower. This, the lecturer pointed out, could hardly fail to be destroyed by quick fire, or at all events the connections from it to the various parts of the ship. He argued, with much reason, that what we cannot protect we ought as far as possible to conceal. Unsatisfactory as armor may be, seeing that it cannot meet torpedo attack, the lecturer thought that the introduction of quick fire and smokeless powder had made it more than ever necessary.

From his review the lecturer concluded that in naval actions it will now be important to develop as heavy a fire as possible for a short time, with a view to which as many guns as possible of adequate power should be mounted. Coals will have to be replenished so often that other stores can be filled up at the same time, and all available weight should be devoted to offensive power. The naval architect's progress is now difficult, seeing that ships are a mark for destruction above and below water. Admiral Long seemed to think that there was much to recommend increased displacement.

FEBRUARY 12 and 19. The Sims-Edison electrical torpedo.

A trial run of the Sims-Edison electrical torpedo took place at Spithead on Wednesday, February 3d, in the presence of H. R. H. the Duke of Connaught and a number of distinguished military officers. The run was conducted from on board the S. S. Drudge.

The controlling switches and other instruments were set up in a small house on the bridge.



On the left is the main switch for putting the current on or off; next to it is the firing switch, held in its normal position by an ebonite safety plug. With the firing switch in this position, main current from the dynamo goes away to the torpedo in a certain direction through the outer core of the cable and works the motor; but if it is put over the other way the current is reversed, and then actuates a polarized relay which sends a shunt current through to the detonator and so fires the charge. On the right is the steering switch, similar to the firing switch, but larger, which controls the current from a storage battery, and sends it through the inner core of the cable in either direction as required. This current actuates the steering relay in the torpedo, causing the main current on its way to earth from the motor to work the steering electro-magnets in the tail of the torpedo. The switch is so arranged that if the lever is set to the right the rudder goes to the right, as also the torpedo; if to the left, the torpedo goes to the left; while if the lever is central, the current is cut off from the steering magnets, and the rudder assumes a central position by the action of the water. On the left of the switch-board are placed a Weston voltmeter reading up to 1550 volts, and an ampèremeter reading up to 50 ampères. Above these is a large resistance box with a controlling handle for putting more or less resistance in the shunt of the dynamo, and so increasing or decreasing the current supplied, and therefore the speed of the torpedo, which may be caused to range almost instantly between 5 and 21 knots at the will of the operator. To the right of the resistance box is a double fuse on the main circuit, for

safety in case of short circuit, and the only other instrument is an electric bell for signaling to the dynamo-room.

All these things having been explained by Mr. Sims, he signaled to run the dynamo, and the men were stationed for launching the torpedo, and the steadying lines were cast off. The Drudge was put to full speed opposite Fort Monckton, and headed toward the Spit Fort, and the order was then given to launch. This was achieved by one man cutting a spun-yarn stop, when the carriage being free to run along on the overhead beam, it started steadily, carrying with it the torpedo with its screw already in motion, and arriving near the end of the beam, the automatic tripper was actuated, and torpedo dropped into the water with a slight dive, going well clear of the ship's side, and the current being increased, it at once gathered way and started off on its journey. As the main object in view was to show the controlability of the torpedo, Mr. Sims did not put on the maximum current, but after running the torpedo to the left on a zig-zag course for a short time to show its steering qualities, he ran it right across the Drudge's bows at a good speed, and finished off with an *S* curve in the direction of Gilkicker Point.

The total length of run was about a mile and a half.

The weather, which had been threatening during the forenoon, improved very much towards evening, which materially assisted the picking up work. The sea was, however, very rough, owing to there being a fresh breeze blowing and to the heavy gales of the preceding three days, notwithstanding which there was no difficulty experienced in launching and controlling the torpedo, which cut its way right through the opposing waves with a force which at times almost completely buried the float, eliciting from the officers a favorable opinion of its power and strength of construction, which should enable it to stand severe weather without injury.

On Tuesday, February 9th, a further trial of the Sims-Edison torpedo took place in Stokes Bay, in the presence, however, of only a couple of visitors. The weather was fine and the sea smooth, and the run was very successful in every way, the steering being perfect and the speed about eighteen knots. It should be noted here that this torpedo has been used continually and much knocked about during the last four years, besides which several additions have been made to it to enable it to be conveniently lifted and launched from a ship, which have all tended to reduce its speed of twenty-one knots previously obtained at Havre, to a lower figure.

All who have had to do with new inventions are well aware that their course, like that of true love, never did run smooth, and if none but successes were chronicled in connection with them, less rather than more confidence in their merits would be inspired.

The next thing, therefore, is to tell of a failure. On Friday, February 12th, a large and distinguished party of officers and others assembled on board the Drudge to witness a trial run in Stokes Bay, the weather being fine and the sea smooth.

After a little time spent in explaining the parts and action of the torpedo, Mr. Sims gave the order to launch, the propeller already revolving in the air at some 700 revolutions. The torpedo moved along the traveler-beam and then plunged into the water, but immediately afterwards it was seen that something was wrong, as it refused to move, and the instruments gave indications of a short circuit in the cable. The picking-up boat was then ordered away to anchor the torpedo, and the Drudge having nearly run out her half mile of cable, the end was slipped and buoyed. Measurements showed that the break was near the junction between the torpedo cable and the ship cable, and Mr. Sims therefore gave orders to cut the cable near this junction, bring the end to the switch-board, and so enable him to run the torpedo from the ship, motionless or at anchor. It was now discovered that, for the first time, and probably because of a larger propeller being used without sufficient guard, the cable had fouled the propeller, and had, of course, been cut. The tube which formerly carried the cable abaft the propeller had been removed after the first trial at New-

castle, as it did not seem to be required, and the guard round the propeller was relied on to keep the cable clear, but it is needless to say that it has now been replaced.

The torpedo was now brought alongside and lifted so as to clear the screw, and then lowered away and towed clear of the ship, and very shortly the current was applied, and it moved away, at first slowly, but very soon getting up a speed calculated at nineteen knots. Now, however, a new trouble occurred, as after answering helm twice, the torpedo would no longer steer, but simply took a long curve to the right, and finally ran close inshore near Browndown, having previously been slowed. It was soon discovered that this trouble was due to no defect in the steering mechanism, but simply to a loose connection of the secondary battery fuze, the terminal having probably jarred loose. This is, of course, instructive, and shows how necessary it is to provide against mishaps trifling in themselves but which may be the causes of so much mischief. As there remained nothing now to be done except pick up the torpedo and cable, the party re-embarked in their respective steamers and returned to harbor, no doubt fully impressed with the idea that the thing is no good. It must fairly be said, however, that although natural under the circumstances, this impression would be an erroneous one, as time, no doubt, will show.

Another run was made on February 15th, which was perfectly successful. The distance covered was something over one nautical mile, and the torpedo was running against a two-knot tide, and was estimated to be going at about eighteen knots through the water. The current at the switch-board was 25 ampères at 950 volts, and the horse-power available at the motor was calculated at about 24.

Military ballooning. Woolwich Arsenal and private manufacturers. French trials of Elswick quick-firing guns. Triple-expansion engines in the mercantile marine.

FEBRUARY 26. Collapsed furnace-crowns of marine boilers.

MARCH 4. H. M. S. S. Ramillies and Repulse.

The engraving which will be found on page 194 gives an excellent idea of what the Ramillies and her sister ship, the Repulse, will be like when finished and at sea. They are both extremely powerful men-of-war; probably the most powerful in the world, not excepting the great Italian vessels. They are steel, twin-screw, double-barbette battleships of 14,150 tons displacement, measuring 380 feet long and 75 feet broad, and having a mean draught of 27 feet and 6 inches. The engines of the Repulse, which are vertical triple-expansion, will develop 9000 horse-power with natural draught, and will drive the ship, it is expected, at a speed of 16 knots. With forced draught they will develop 13,000 horse-power and give a speed of 17.5 knots. The ship will carry 900 tons of coal, which will enable her to steam 5000 knots at 10 knots an hour without refilling her bunkers; but, in case of necessity, she will be able to stow about 400 tons more, and so obtain an anticipated radius of over 7000 knots.

The chief weights to be carried are the armament, 1910 tons, and the armor, 4550 tons. At each end there is a section 65 feet long which is entirely without vertical armor, the only protection there being afforded by a 2½-in. steel deck. The whole middle section of the ship is furnished with a water-line belt of a maximum thickness of 18 inches, 250 feet long, and extending 5 feet 6 inches below and 3 feet above the line of load-draught immersion. The ends of the belt are joined by transverse armored bulkheads which rest upon the armored deck. At each end of the armored enclosure which is thus formed there rises to above the level of the upper deck a barbette composed of 17-in. armor. On the top of the armored belt rests a 3-in. steel deck, and above this, to a height of some feet, the outer walls of the ship are composed of 4-in. steel upon a 1-in. steel skin. Again, above this there is armor in the shape of steel shields to the larger broadside guns. Finally, there are two

armored conning towers. one forward composed of 14-in., and one aft composed of 3-in. plates. Each barbette is a separate and very strong pear-shaped two-storied redoubt. In the upper story is the turntable carrying the guns; in the lower are the turning engines, etc.; and as the whole structure is thickly armored all the way down to 5 feet 6 inches below the water-line, there is obviously little danger of a hostile shell putting the heavy guns out of action by exploding beneath them. The tops of the barbettes project but 2 feet 9 inches above the upper deck; consequently the axes of the guns are only about 4 feet 6 inches above that deck.

The freeboard of the Repulse and her sisters will be 18 feet, and the heavy guns themselves will be 23 feet above the water, instead of 20 feet as in the completed Admirals. The chief armament of the Ramillies and Repulse will consist of four 13.5-in. 67-ton guns, disposed two in each barbette. These have arcs of training of about 200 degrees, and all four guns can be simultaneously discharged on either broadside. The secondary armament will consist of ten 6-in. quick-firing guns of 40 calibers. These are carried in the box battery between the barbettes, two on each broadside being on the main deck in sponsons, and three on each broadside being on the upper deck. The tertiary armament consists of sixteen 2.24-in. 6-pounder quick-firing guns, twelve of which are on the main and four on the upper deck; ten 1.85-in. 3-pounder quick-firing guns on the upper deck and superstructure and in the tops; eight machine guns, and, for landing purposes, two 9-pounder field-guns. There will also be five above-water and two submerged torpedo tubes. The total estimated cost is £831,678.

MARCH 11. The navy of the United States, No. IV.

A description of the "coast-line battleships" and "commerce destroyers," with illustrations. The article includes the following table (see next page):

New Elswick disappearing carriage for 6-in. B. L. gun (illustrated). Ascertaining distances and directions at sea.

This method of measuring distances at sea, devised by H. P. Dowling, "consists essentially in the employment of apparatus for sending sound signals simultaneously through air and through water, and apparatus for receiving and registering the sound so sent, so that the difference in time of arrival through both media may be used to indicate the distance"; the velocity of sound in air and in water being about 1100 feet and 4400 feet per second respectively.

Bounties on ship-building in France.

The navy estimates and ship-building programme.

Table showing Progress made in the Programme of the Naval Defense Act of 1889.

	Total number voted.	To be built by contract.			To be built in navy yards.		
		Total.	Delivered or launched.	To be completed before or in 1894–95.	Total.	Completed.	To be completed before or in 1894–95.
Armored battleship, first-class, *i. e.*, 1 turret and 7 barbette ships	8	4	1	3	4	1	3
Do. second class	2	..	.	..	2	..	2
Protected cruisers, first class	9	5	2	3	4	..	4
" " second class	29	17	11	6	12	2	10
" " third class	4	..	..	..	4	4	..
Torpedo gunboats	18	6	..	6	12	2	10

A Comparison between the most recent Battleships and Cruisers of the United States and Great Britain.

PARTICULARS.	Armored.			Unarmored.			Remarks.
	Indiana, Massachusetts and Oregon.	Centurion and Barfleur.	New York or (Number 2).	Royal Arthur.	Nos. 12, 13. "Commerce Destroyers."	Blake and Blenheim.	
Class or Designation.	Coast-line Battleships.	Second Class Battleships.	Armored Cruiser.	First Class Protected Cruisers.	Protected Cruisers.	First Class Protected Cruisers.	
Displacement, tons	10,298	10,500	8150	7700	7475	9000	
Indicated horse-power, maximum	9,000	13,000	16,500	12,000	21,000	20,000	
Length	348 feet.	360 feet.	380 ft. 6 in.	360 feet.	412 feet.	375 feet.	
Beam	69 ft. 3 in.	70 feet.	64 ft. 10 in.	60 feet.	53 feet.	65 feet.	
Draught	24 feet.	25 feet 6 in.	23 ft. 3½ in.	23 ft. 9 in.	23 feet.	25 ft. 9 in.	
Speed, knots	16¼ Sea speed 15	18	20	19.50	22 Sea speed 21	22 Sea speed 20	Maximum.
Coal capacity, tons	1800	750 or 1125	1500	850	2000	1500	
Endurance, at 10 knots per hour	16,000*	6500 or 9750	13,500*	10,000*	26,240*	15,000*	Knots *Query?
Side armor, belt	18-in.	12-in.	5-in.	none.	none.	none.	
Armor of upper works	5-in.	4-in.		none.	none.	none.	
Protective deck	3-in. & 2¾-in.	2½-in.	6, 3, & 2½-in.	5-in. and 3-in.	4-in. & 2½-in.	6-in. and 3 in.	Maximum thickness on slopes of deck.
Cost	£604,000	£607,746	£597,000	£377,230	£545,000	£433,755	
Armament, guns	4 13-in. B.L.R. 8 8-in. " 4 6-in. " 26 light.	4 10-in. B.L.R. 10 4.7-in. Q. F. 20 light.	6 8-in. B.L.R. 12 4-in. " 16 light.	1 9.2-in. B.L.R 12 6-in. Q. F. 28 light.	1 8-in. B.L.R. 2 6-in. " 12 4-in. " 28 light.	2 9.2-in. B.L.R 10 6-in. " 24 light.	All fitted with torpedo tubes.

With regard to heavy guns, the First Lord gives the following table, showing the progress made in gun manufacture during the year. The total number of guns completed during the year ended December 31st, 1891, was 396, as compared with 240 in the preceding year:

Nature of Gun.	Numbers Completed.
16.25-inch of 110 tons	1
13.5-inch of 67 tons	21
10-inch of 29 tons	10
9.2-inch of 22 tons	19
8-inch of 14 tons	1
6-inch of 5 tons	75
5-inch of 40 cwt.	22
4-inch of 26 cwt.	8
6-inch quick-fire	8
4.7-inch quick-fire	225
Total	390

The number of guns mounted and ready for ships on December 31st was 1623, against 1410 at the end of 1890.

The following table deserves attention, dealing as it does with *personnel* as well as *matériel*:

	1886.	1892.
Ordnance:		
Breech-loading guns (afloat and in reserve)	499	1,868
Light quick-firing guns (afloat and in reserve)	33	1,715
Torpedoes (afloat and in reserve)	820	2,874
Ships (fighting):		
In commission—		
At home—excluding coast-defense ships, gunboats and torpedo-boats	15	21
Displacement tonnage	110,000	154,500
Abroad—total of all classes	96	110
Displacement tonnage	205,800	300,007
Complements—abroad	18,100	23,350
In reserve (ready for commission):		
Excluding coast-defense ships, gunboats, and torpedo-boats—		
Fleet reserve—		
Division A	....	6
Division B	....	11
Old first-class steam reserve	10	2
Displacement tonnage	25,700	82,200
Ships of 15 knots speed and upwards (afloat and building) all classes except torpedo-boats	57	140
Personnel:		
Establishments of officers and men (active list)	61,400	74,100
Numbers of Royal Naval Reserve (officers and men)	18,300	25,500

MARCH 18. The navy of the United States, No. IV (concluded).

Includes description of Cruiser No. 12.

Photographing bullets. H. M. S. Hawke.

The first set of trials was made on March 5th, on an eight hours' run, the speed being determined by log. There was an air-pressure of about .3 inch of water in the stokehold. Under these conditions the engines worked at an average rate of 98.46 revolutions per minute, indicating 10,761 HP, which gave a mean speed of 19.5 knots.

The next runs were made on March 8th, under a moderate forced draught of .44 inch water-pressure. During a four hours' run at an average rate of 102.18 revolutions per minute, 12,521 indicated horse-power were developed, 521 above contract requirement.

Boilers in the navy.

MARCH 25. An unconsidered phase of cylinder condensation. Improved Martin anchor.

APRIL 1. The S. S. Ruahine. The American champion armor-plate. The Serve tube.

APRIL 8. Buoying and lighting tidal rivers, No. 1 (illustrated). On balancing marine engines and the vibration of vessels (illustrated). The vibration of torpedo-boats. A new method of hydraulic propulsion. Steam trials of H. M. S. Sybille.

APRIL 15. The Institution of Naval Architects. The Russian navy. Military aeronautics. Controlled torpedoes.

APRIL 22. H. M. S. Blake. Victor turbines. Speed in the navy. Giant lighthouse lens.

THE IRON AGE.

VOLUME XLVIII, NO. 9, AUGUST 27, 1891. Threading and slotting machine for guns of 8 to 12 inch caliber (illustrated). Breaking the ocean record. The gun works of Krupp, Armstrong, and Canet (illustrated).

The recent bids submitted by the gun manufacturers of the United States for supplying the army with 100 modern high-power rifled breech-loading guns call attention to the manufacture of such ordnance in foreign countries.

The largest gun works in the world are those of Krupp, at Essen, in Germany. The plant complete covers 600 acres of ground and furnishes employment for 11,000 men. Besides the factories, Herr Krupp owns several hundred iron mines in Germany and a half-dozen in Bilboa, Spain, and to these iron mines should be added several coal mines. It is estimated that the daily output from these mines is 3000 tons of coal and 15,000 tons of ore, and that this part of the work employs 6000 workmen. Krupp has 14 blast furnaces belonging to six smelting works. A complete railroad and steamship service forms part of the vast and complex system. There are also hospitals, insurance associations, villages and a complete social organization that go toward making the Krupp establishment a community to itself. This community numbers some 25,000 workers, all more or less engaged in the production of iron and steel. The value of the plant is estimated at not far from $50,000,000.

The second great gun-making establishment of the world is probably that of Sir W. G. Armstrong, Mitchell & Co., of Elswick, at Newcastle-on-Tyne, England. These works claim that in point of importance and extent they have no other rivals than Krupp. The firm not only make artillery, with all its accessories, but also possess excellent shipyards, from which the largest vessels can be turned out, for either the mercantile or naval marine. For all these purposes the Armstrong Company employ no less than 16,500 men.

The most important ordnance establishment in France is that of the Société des Forges et Chantiers de la Méditerranée. This corporation has three factories, one at Havre, one at Marseilles and one at La Seyne, near Toulon. That branch of the works situated at Havre is chiefly occupied with the manufacture of guns, under the superintendence of Mr. Canet, whose great success has given the name of Canet to all the guns now made by him. The number of

workmen he employs is about 10,000. Canet is a rival of Armstrong, though the latter may not think so, and several nations consider his guns as superior.

Russia has a large steel and gun-making plant at Aboukoff, near St. Petersburg, but there are many Krupp cannons in use in the Russian army and navy. There are many other gun factories besides those mentioned above, but their size and capacity are not to be compared with them.

A glance at the largest guns each of the above firms has turned out may be interesting. Krupp has manufactured the largest cannon in the world, 119 tons in weight. Armstrong, Mitchell & Co. follow with a gun of larger bore, but lesser weight, and Canet brings up the foot of the list with a gun of 66 tons. . . The big gun of Germany costs the sum of $144,750. Three of them were bought by the Italians for coast defense use. England's 111-tonner is worth $93,160. Some of them are mounted on board a couple of the new battleships. The smaller gun—that of France—can be bought for, let us say, $50,000. As more details of this monster ordnance may be desired, the following tables are subjoined:

Gun Maker.	Weight. Tons.	Diameter of Bore. Inch.	Powder Charge. Lbs.	Projectile. Lbs.	Muzzle Velocity. F. S.	Muzzle Energy. F. T.	Penetration in Steel at the Muzzle. Inch.
Armstrong....	111	16.25	960	1,800	2,148	57,580	30.8
Krupp........	119	15.75	727.5	2,028	1,804	45,970	27.1

To make comparison between the guns of the three celebrated gun makers, the same size of gun must be taken—thus:

	Tons.	Inch.	Lbs.	Lbs.	F. S.	F. T.	Inch.
Armstrong....	67.0	13.5	630	1,250	2,025	35,540	26.6
Canet........	65.8	13.4	616	990	2,300	36,317	29.1

There is no Krupp gun of 13 inches to place with the other two. Krupp's 12-inch gun is the nearest and that is too inferior to enter. The table shows the superiority of the Canet gun.

FEBRUARY 11 and 18, 1892. The Michelson range-finder. Torpedo-net protection.

MARCH 3. Smokeless powders. The Dundon compound steam boiler. The Brown wire-wound gun.

MARCH 10 and 17. Smoke consumption. Legislation affecting marine boilers. William Cramp & Sons Ship and Engine Building Company. American armor (illustrated).

MARCH 24. United States naval steam cutters (illustrated). The submarine cables of the world.

MARCH 31. The Sigua iron mines. Gun-boring machine.

APRIL 7 and 14. The English navy. The firing speed of machine guns. The Serve boiler tube. Uses of aluminium, I.

APRIL 21 and 28. Torpedoes. The uses of aluminium, II. The Zell steel water-tube boiler. Bethlehem barbettes.

ENGINEERING.

FEBRUARY 5, 1892. Canet vs. Krupp guns. Quick-firing guns in the navy. Steam trials of H. M. S. Edgar. H. M. S. Grafton.

FEBRUARY 19. Trial of H. M. S. Edgar. Military ballooning.

MARCH 4. The life-saving and salvage steamer Aid. H. M. battleship Ramillies. Railways in war-time.

MARCH 11. The training of Royal Naval engineers. 30.5 centimeter cast-iron howitzer.

This 12-inch cast-iron built-up howitzer was constructed at the Fabrica de Trubia, Spain. It was designed by a Spanish artillery officer and passed satisfactory tests. The breech of the gun is built up of steel rings shrunk over the cast-iron A-tube, while the breech mechanism is on the interrupted screw principle. The principal dimensions are, caliber 12.01 inches, weight 14.27 tons, length of bore 12.5 calibers, preponderance 132.23 pounds, weight of charge 77.16 pounds, volume of chamber 3051 cubic inches, weight of projectile 606 3 pounds, initial velocity 1129 feet, range for 45 degrees 10,717 yards, number of grooves 48.

The navy estimates. Combined centrifugal and positive action pumps.

MARCH 18. The construction of theoretical indicator diagrams for compound engines. Modern United States artillery, No. I (illustrated). Steam boiler experiments, No. VIII. Navy boilers. Breakdowns in the navy.

MARCH 25. Formosa and its railways. Modern United States artillery, No. II (illustrated).

Description of standard light 3-inch rifle, of converted 8-inch and 10-inch smoothbores, as well as of projectiles for converted guns.

The employment of ships. How fast a single-barrel machine-gun may be fired.

APRIL 1. Modern United States artillery, No. III (illustrated).

Converting wrought-iron 3-inch guns; description of manufacture of 3.3-inch steel B. L. R., model 1889.

Canet vs. Krupp guns. The Serve boiler tube.

APRIL 8. Modern United States artillery, No. IV (illustrated).

Description of breech mechanism of 3.2-inch B. L. R., model 1889.

Balancing of marine engines and the vibration of vessels. Water-tight bulkheads. Circular furnace-stoker.

APRIL 15. Modern United States artillery, No. V (illustrated).

Description of carriage, limber, and harness for 3.2-inch B. L. R.

Institution of Naval Architects. Steadying vessels at sea. Whaleback steamers. An approximate rule for the center of buoyancy. Vibration of vessels. Balancing of marine engines and the vibration of vessels (illustrated). Water-tight bulkheads (illustrated).

APRIL 22. Modern United States artillery, No. VI (illustrated).

Description of 3.6-inch heavy field-gun, its ballistic data, ammunition, fuzes.

Institution of Naval Architects. Field howitzers and mortars.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

NINTH ANNUAL SERIES, 1891, VOLUME XII. Hydrographic notes on New Guinea. Agreement of weather characteristics in northern

Germany (concluded). Tides and currents in the roadstead of Hangkow in the Yantse Kiang. Currents and sea temperatures on the west coast of South America. Sailing directions for Zanzibar. Report of Captain F. Duhme, of the German steamer Tai-cheong, on the typhoons of July, 1891. Extracts from the reports of the masters of ships Aeolus and J. W. Gildenmeister (notes on ports in various parts of the Pacific Ocean, as well as on the passage through Torres Straits). Voyages in the Gulf of California and along the west coast of Mexico. Deep-sea soundings in the East Indian archipelago. On the effect of the direction of the wind and atmospheric pressure upon the surface of the sea; Chronometer comparison based on their methods of compensation. Quarterly weather review of the German Naval Observatory, spring of 1887. Minor notices: Remarkable meteoric phenomena; Anchorage for war-vessels in the harbor of Piraeus: Anchorage on north side of Pajaros Island, Mexico; Antofagasta.

THE UNITED SERVICE.

APRIL, 1892. The building of the soldier. Priscilla. A lesson from history. Riots and means for their suppression. Street fighting, by Henry Romeyn, Captain 1st U. S. Infantry. Capture of the United States revenue cutter Surveyor. Company discipline. Marbot.

MAY. Wagon and rail transportation. Recollections and incidents of a cruise around the world. Napoleon the Third at Sedan. History of first fight and organization of Stonewall Brigade. Civil employment of troops. Chronicles of Carter barracks. The captain's story. Captain T. O. Selfridge, Jr., U. S. Navy.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

MARCH, 1892. Position-finding service. Army transportation. Was Gettysburg decisive? Artillery service in the Rebellion. Infantry fire. Shrapnel fire. Power of military courts to punish for contempt. Reprints and translations: The progress of tactics; Smokeless powder; Coast and harbor defense; Canet vs. Krupp guns; Changes in military matters; Letters on infantry, XIV. Military notes: The German torpedo-shell; Mannlicher bullets; Coast batteries.

MAY. The military geography of Canada. Artillery in the Rebellion. A plea for the colors. Diseases which have been epidemic in armies. Post schools in the army. Reprints and translations: Military small-arms; The progress of tactics; Staff duty in the Peninsular army; Letters on infantry; Experiments with field mortars. Military notes: Modern military rifles; Photography and reconnoissance; Improvement of Scott's telescopic sight; The Krag-Jörgensen rifle.

FRANKLIN INSTITUTE.

MARCH, 1862. Bearing-metal alloys. The proposed ship-canal between New York and Philadelphia, connecting the Delaware and Raritan rivers. The development of spiral weld tube machinery. Philadelphia as a seaport, by Capt. F. A. Mahan, U. S. A. Electrical section: An early conception of the magnetic field; Notes on electro-magnetic machinery, by Wm. S. Aldrich.

APRIL. Aluminium, its manufacture and uses, from an engineering standpoint, by A. E. Hunt. Philadelphia as a seaport. A computation of Joule's equivalent (concluded). Chemical section. Electrical section: Resistance standards, their manufacture and adjustment; On the variable action of two-coil solenoids. Photographic novelties.

BULLETIN OF THE AMERICAN GEOGRAPHICAL SOCIETY.

VOLUME XXIV, NO. 1. Exploration of the Grand River, Labrador. Who discovered the Pygmies? Rivers and the evolution of geographic forms. U. S. atlas sheets and census bulletins. Geographical notes.

UNITED SERVICE GAZETTE.

MARCH 5, 1892. Photography and reconnoissance. Launch of the Repulse and of the Ramillies. Carrier pigeons.

The census of carrier pigeons taken in Paris between January 1st and 15th last shows that there are 697 proprietors, possessing 13,892 birds. The census enters into very minute particulars as to the respectability of the owners, and the direction in which the pigeons are trained to fly, so that in case of war the military authorities on taking over the birds would be in a position to utilize them to the best advantage.

MARCH 12. Naval gunnery.

"Before allowing a seaman to fire he should be put through a course of drill which should be most carefully carried out; and no man ought to be allowed to fire a shot until he has proved himself efficient at drill. . . . . The executive officer may be said to take no interest whatever in anything appertaining to gunnery. It dirties his paint-work and boats, interferes with his routine, and occupies men who would otherwise be at his disposal; so he gives the men with a bad grace, often remarking that gunnery is 'all rot.' This officer and the gunnery lieutenant are, therefore, generally working at cross purposes, and the former will often put serious obstacles in the way of the drills, and the men who are under instruction are made to feel that if not employed in that way they might be at leisure, the result being a cordial hatred of gunnery drills. It is a curious fact that executive officers who have themselves been gunnery officers are frequently antagonistic to their old chosen specialty; gunnery has been to them a stepping-stone to promotion and is now of no further interest. The executive officer is not alone to blame in this matter. It must be remembered that his promotion depends almost entirely on the general appearance of his ship, its cleanliness, and the efficiency of the ship's company apart from gunnery.

The only remedy that suggests itself is that there should be a senior officer on the staff of the admiral in each squadron appointed for the superintendence of gunnery drills and exercises."

The Russian navy. The terrain in its relations to military operations, IV. The navy estimates. Quick-firing guns in the French army.

MARCH 19 and 26. Naval manœuvres of 1891. The use of pigeons for naval and military purposes. The Royal Naval Reserve. Ships, engines and boilers.

Apropos of the rapid diminution which has been made in recent years in the bores of military rifles, the *Revue Scientifique* gives the following table of rifles which have been adopted since 1866:

State.	Year.	Caliber. mm.	System.
France,	1866	11	Chassepot.
United States,	1866	11.43	Springfield.
Belgium,	1867	11	Albini.
Austria,	1868–73	11	Werndl.
Switzerland,	1868–81	10.4	Vetterli.
Spain,	1871	11	Remington.
Germany,	1871	11	Mauser.
England,	1871	11.43	Martini.
Holland,	1871	11	Beaumont.
Italy,	1871	10.4	Vetterli.
Russia,	1871	10.66	Berdan.
France,	1874	11	Gras.
Portugal,	1885	8	Gnédes.
France,	1886	8	Lebel.
Austria,	1888	8	Mannlicher.
Germany,	1888	7.9	Mannlicher.
England,	1889	7.7	Lee-Metford.
Belgium,	1889	7.65	Mauser.
Switzerland,	1890	7.5	Mauser.
Italy,	1892	6.5	Mauser.

APRIL 2. Launch of the Crescent. Naval notes: Launch of the Bouvines.

The Bouvines has a displacement of 6610 tons, 284 feet between perpendiculars, breadth 55 feet, draft 24 feet 4 inches. She has two sets of triple expansion engines, giving 7500 HP and a speed of 15 knots. The hull has an armored belt of 17¾-inch plating; the steel deck varies from 2¾ to 3.9 inches in thickness. Her armament will consist of two 32-cm. guns mounted in heavily armored hydraulic pivoted turrets, eight 10-cm. quick-firing guns, eight 38-mm. revolving guns and two 47-mm. machine guns in the tops.

APRIL 9. The shooting of field artillery. Institution of Naval Architects. The Royal Naval Reserve.

APRIL 16. Field artillery tactics. Field howitzers and mortars.

APRIL 23. The physique of the army. Quick-firing guns. The use of balloons in warfare.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

APRIL, 1892. The telephone at home and in the field. The reconnoissance of a railway; its utilization and destruction in time of war. The naval prize essay, 1892: "Maritime supremacy being essential for the general protection of the British Empire and its commerce, to

what extent, if any, should our naval force be supplemented by fixed defenses at home and abroad, and to whom should they be confided?" by Captain R. W. Craigie, R. N.

The writer first considers the question of defenses ashore in England. According to the relative importance of the ports to be guarded, the defenses are ranged under four classes. The floating coast defenses are next considered, followed by the fixed defenses abroad. The different trade routes of England are taken up in order and the needs of defenses are thoroughly considered. The essay winds up with the following conclusions:

"1. That to the Navy should be entrusted the duty of sweeping the high seas and of keeping them clear of the enemy's cruisers.

2. That, after our maritime supremacy has been assured by building a sufficient number of ships, our naval force should be supplanted by certain fixed defenses raised to meet a definite purpose at our different ports at home and abroad; this purpose being to resist a raid or attack by one or more cruisers for a few days, and to offer a safe refuge for our war-ships and mercantile marine while coaling, loading or unloading, or under repair.

3. That these fixed defenses are of little use, since they could not keep the entrance of the port clear, or prevent the attack of torpedo-boats, without a floating defense, consisting of torpedo-boats and armed local steamers acting as guard-boats.

4. That these fixed defenses should be under military control, but that all the purely naval or maritime portion of the defenses should be manned and worked by seamen under a naval officer attached to the staff of the general officer in command.

5. To avoid, however, breaking up regiments into small detachments unnecessarily, certain small coaling stations abroad should be manned by marines and seamen and placed under naval control.

6. That the only way that our naval and military forces can be kept in their proper proportion, and used with the greatest effect, is to place them both under one minister."

Essay honorably mentioned: "The employment of Photography in reconnoissance." Modern rifle bullets and their effects. The naval schools of the chief continental powers, Part III.

TRANSACTIONS OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

Vol. IX, No. 1. The commerce of San Francisco, with discussion, George W. Dickie.

MÉMOIRES DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

REVUE DU CERCLE MILITAIRE.

FEBRUARY 14, 1892. Surgical antisepsy in the army.

This is the title of an unpretending but useful memorandum pocket-book that can be easily consulted even on the battle-field.

Notes on the Austro-Hungarian army. Adaptation of the commissariat wagons to ferry-boats for the passage of troops over streams and narrow waters.

FEBRUARY 21. Surgical antisepsy in the army (continued). Notes on the composition and organization of the Austro-Hungarian army.

FEBRUARY 28 and MARCH 6. Antiseptic operations and dressing in the army (with sketches).

MARCH 13. Interior life of the private in the English army. Organization of the reserve in the Portuguese army.

MARCH 27. Military strength of Morocco. Antiseptic operations, etc. (continued). Notes on the Austro-Hungarian army (ended).

APRIL 10. Practical instruction in the military academy of Toledo (Spain). A study on infantry tactics, continued from the preceding number. Antiseptic operations, etc. (ended).

APRIL 17 and 24. A study on infantry tactics (ended). The adjustable boat of Lieutenant Van Wetter of the Belgian army.

A full description of this contrivance will be found in this and the following number of the Review. It is destined to render great service and unites the following advantages: 1, great strength; 2, minimum weight and facility of transportation; 3, small volume; 4, rapidity in taking apart and putting together; 5, possibility of the wood-work being built and all repairs made by the troops; 6, smallness of cost; 7, keeping in repair next to nothing.

MAY 1. The "lava" of the Russian Cossacks and their modes of fighting. Use of railroads during the Turko-Russian war (continued). New firing regulations in the Italian army. The crossing of streams during army operations.

This is one of the important problems that preoccupy the minds of military men, which assertion requires no better proof than the numerous articles lately written on the subject (see article published in the Revue of April 24).

LE YACHT.

JANUARY 30, 1892. Transformation of the 28-caliber gun into a R. F. cannon. A proposition to turn over the coast defenses to the unemployed part of the naval reserve, in case of mobilization.

FEBRUARY 13. A lecture by Rear-Admiral Sam. Long on the influence of the rapid-fire gun on naval tactics. A new system of screws devised for engines turning in the same direction.

FEBRUARY 20. The Russian navy. Of the necessity of establishing electric communication between the semaphoric coast-stations. On the use of aluminium in yacht-building.

FEBRUARY 27. The R. F. gun. "Union of French Yachts": Admissions; Regulations for the Cup of France; Programme of 1892.

Thinking that the regulations governing the race for the Cup of France might prove of interest to yachtsmen on this continent, we give below a translation of the same:

Art. I. The Cup of France, founded by the "French Yacht Association," and transferred to the "Union of French Yachts," constitutes the prize for an international race, to be sailed on and after the year 1892, and which can be entered by all yachts conforming with the following rules:

Art. II. The cup is and shall remain the property of the Union. Its possession by the owner or owners of the winning yacht shall be only temporary.

Art. III. The race for the cup shall be sailed in French waters between July and October, and at a place designated by the Union before the 1st of March in each year.

Art. IV. The regulations governing the race shall be those of the Union of French Yachts.

Art. V. Shall be admissible to compete in the race, yachts of all nations, with any kind of rig, standing keel, or center-board, whose tonnage shall be superior to 5 tons, and not over 20 (French measurement).

Art. VI. Foreign yachts in order to be qualified must have been built in the country whose flag they display.

Art. VII. Shall be admitted to compete, only those French yachts whose plans have been designed by a French builder, have been built and equipped (including sails) in France, and shall be manned by a French crew.

Art. VIII. Foreign yachts intending to proffer a challenge must give notice of their intention before the 1st of April of each year.

Art. IX. Yachts intending challenging a foreign club holding the cup must also notify the fact through the "Union of French Yachts," and at the same date as in Art. VIII.

Notices of challenge shall furnish. 1, the name of the owner; 2, that of the yacht; 3, the necessary dimensions for measurements, or a certificate delivered by the Union; 4, the yacht's rig, her origin, and her date of construction, whether of wood, iron, steel, or composite; a fac-simile of her racing pennant, and finally, an honorable pledge not to contest before tribunals any point of difference arising from possible incidents of the race, and to sign, if need be, a pledge of amicable arbitration.

Art. X. A challenge having been forwarded to the holder of the cup, the latter shall forthwith give the names of the yachts accepting the challenge, and this before the 1st of June of each year.

Art. XI. If no challenge shall have been received before the 1st of April, the race will be postponed till the following year. Should none of the yachts having sent the challenge present themselves at the starting point, then an adjournment shall likewise take place.

Art. XII. Should no yacht take up the challenge, the cup will be handed to the yacht having sent the challenge. Should there be several yachts entered for the race, they will sail over the course to determine the victor, the same as if the challenge had been taken up.

Art. XIII. The course shall be sailed over three times in succession. The details will be published every year in a special programme made out by the Union of French Yachts. Each trial will be over a course of not less than 20 nautical miles, and the yachts shall sail over it at mean rate of 3 miles an hour, otherwise the race shall be declared off. The yacht reaching the stake first in two runs shall be declared the winner; if she should win the first two, the third will be dispensed with.

Should each run be won by yachts of different nationalities, or several yachts of the same nationality, the final victory shall be decided by a fourth race.

If two out of three runs shall have been won by different yachts of one nationality, the final contest shall be only between those yachts.

Art. XIV. The challenging club, or the Union of French Yachts, will present the cup to the victorious yacht, whose owner will furnish the necessary security.

Art. XV. The start will take place exactly at the hour fixed, except 1st, in case of some extraordinary circumstance; 2d, in case of a mishap just before the start, in which case the judges will decide whether sufficient time shall be granted or not to repair damages.

Art. XVI. The Union of French Yachts will entrust to a local nautical society the management of the race.

Art. XVII. The Union of French Yachts reserves the right as long as said Union or a Frenchman shall hold the cup, of modifying or changing the conditions of the race before the 1st of February in every year.

Art. XVIII. Letters of challenge shall include a pledge to pay the entrance fee indicated in the programme.

The use of aluminium in yacht-building and its results compared with wood or iron in sailing yachts (see preceding number.) The French armor-clad Jauréguiberry, built at La Seyne by the Forges et Chantiers de la Méditerranée.

MARCH 12. The naval appropriations for 1893 in the French Parliament. A comparison between the English and French armor-clads.

MARCH 19. The English naval budget. A comparison between the English and French armor-clads (concluded).

MARCH 26. The English naval budget in the House of Commons.

APRIL 2. A projected law in regard to the "inscription maritime." Launching of the armor-clad Bouvines. Geometry of the yacht; formula of measurement (see preceding number).

APRIL 9. The navy; the budget; the North squadron; Dahomey; Rear-Admiral Mottez (E. Weyl). Geometry of the yacht; formula of measurement (continued).

APRIL 16. The coast defenses of France. The English first-class cruiser Edgar.

APRIL 30. The navy and Dahomey. The next naval appropriation. The new constructions (E. Weyl). The Maxim-Nordenfelt guns. Launching of the armored coast-defense vessel Jemmapes.

REVUE MARITIME ET COLONIALE.

MARCH, 1892.

The greater portion of this number is taken up with two articles translated from the English, the first being "Problems of Greater Britain," under which title Sir Ch. Dilkes published two years ago, as our readers are probably aware, an exposé of the situation of the British Empire. The second is a translation of the "Latest Great Naval War," the famous production of Mr. Nelson Seaforth.

The boards of administration of navy years (French), ended.

APRIL —. Oceanography [dynamics] (continued). Considerations of the relations between the barometer and the distribution of air-currents. A study upon the mechanical theory of heat. A vocabulary of powders and explosives (continued).

BOLETIN DEL CENTRO NAVAL, BUENOS AIRES.

NOVEMBER, 1891. Military jurisprudence.

An appeal from the action of the Minister of Marine in ordering the arrest of the president (a commodore) and members of a court-martial.

DECEMBER. A relation of the practice cruise of the Argentina during a surveying expedition on the coasts of Patagonia.

JANUARY, 1892. Cares and precautions in the management of chronometers on board ship. Naval guns.

An article in which the author criticises severely the Armstrong and Krupp manufactures of heavy ordnance, adducing as proof of their indifferent quality a numerous list of accidents which have occurred with their system during the last decade.

Continuation of the relation of the practice cruiser Argentina on a surveying expedition to the coasts of Patagonia. Defense of seaport entrances against torpedo-boats. Organization of the Argentine fleet.

REVISTA MARITIMA BRAZILEIRA.

DECEMBER, 1891. Report of the results of Lieut. Portella's visits to European dockyards and shipbuilding establishments to the Brazilian minister of marine; followed by a few notes on the institution of naval apprenticeship among various nations. Smokeless powders in naval battles (translated from the French).

The government manufacture of smokeless powder at Sévran-Livry furnishes powder to the French army and navy. Mr. Canet uses for his guns powder of the above manufacture, adding to it an innocuous substance in order to frustrate any chemical analysis that might be attempted to discover its composition.

JANUARY AND FEBRUARY, 1892. Report of Lieut. Portella (continued). A few notes on the institution of naval apprenticeship among different nations (continued). Smokeless powder C. 89 used by Krupp. A new method of rectifying a table of deviations of the compass.

NAMES OF MEMBERS WHO JOINED SINCE JULY 1, 1891.

LIFE MEMBERS.

Clowes, W. Laird, Prize Essayist, 1892, No. 4 Wyburn Villas, Surbiton Hill, Surrey, England.
Maxwell, W. J., Ensign, U. S. N.

REGULAR MEMBERS.

Brainard, F. R., Ensign, U. S. N.
Dutton, Robert McM., Lieut., U. S. M. C.
Hayes, C. H., Asst. Engineer, U. S. N.
Lowry, O. W., Lieut., U. S. N.
Martin, John R. P., Asst. Paymaster, U. S. N.
McDonald, J. E., Naval Cadet, U. S. N.
Scales, A. H., Ensign, U. S. N.
Snow, T. H., Naval Cadet, U. S. N.
Snow, W. A., Ensign, U. S. N.

ASSOCIATE MEMBERS.

Clapp, T. H., Ensign, Naval Battalion, M. V. M.
Fitzgerald, John J., Lieut., Naval Battalion, N. G., California.
Graham, Geo. H., Counselor at Law.
Hamilton, James, 2d Lieutenant, 3d Artillery, U. S. Army.
Harvey, H. A., Gen'l Manager, Harvey Steel Co.
Rowan Hamilton, 1st Lieutenant, 2d Artillery, U. S. A.
Slater, A. B., Jr., Superintendent, Providence Gas Co.
Smith, F. G., Major, 4th Artillery, U. S. Army.
Sweet, Henry N., 4 Spruce Street, Boston, Mass.
Wadagaki, Y., Japanese Student, London, Eng.
Weaver, E. M., 1st Lieutenant, 2d Artillery, U. S. Army.
Wilson, Thomas L., Electrical Engineer.

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PROCEEDINGS

OF THE

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VOLUME XVIII.

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FIRST AID TO THE INJURED, AND TRANSPORTATION OF THE WOUNDED.

Six Lectures delivered to the Naval Cadets of the First Class at the Naval Academy during the Winter of 1892.

BY HENRY G. BEYER, M.D., PH.D., M. R. C. S.,

Passed Assistant Surgeon, U. S. Navy, Instructor in Physiology and Hygiene, Naval Academy, Annapolis, Md.

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List of Books referred to in the Preparation of the Foregoing Lectures:

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Dr. R. von Mosetig-Moorhof, Die erste Hilfe.

Osborn, Sam., F. R. C. S., Ambulance Lectures.

Porter, J. H., Surgeon-Major, and Godwin, C. H. Y., Brigade-Surgeon, The Surgeon's Pocket-Book.

Dr. Paul Rupprecht, Die Krankenpflege.

Smart, Charles, Major and Surgeon, U. S. Army, Handbook for the Hospital Corps of the U. S. Army.

Dr. Bowditch Morton, First Aid to the Injured.

Medical and Surgical History of the War of the Rebellion, Medical Volume, Part III, prepared by Charles Smart, Surgeon-Major, U. S. Army.

LECTURE I.

INTRODUCTION.

The purpose of these lectures and the demonstrations which will follow them is to give you that knowledge and training which will enable you to administer to your comrades whatever help they may need when injured, and to do it intelligently and with perfect safety.

The desire to aid an injured person and to succor a fellow-creature in misfortune is an attribute of every good man and woman. An acquaintance with the principles of "First Aid to the Wounded," therefore, ought to form part of their education, but it is to soldiers and sailors more especially, who are trained to expose themselves to the dangers of being wounded or otherwise injured, to whom this knowledge seems particularly desirable.

It is, furthermore, intended in this course of instruction to impress your minds with some of the leading and fundamental principles of hygiene, a knowledge of which will enable you to do much toward the prevention of infectious diseases among you, or, in case of an actual outbreak of an epidemic of whatever kind of disease, will at least form a safe guide for your conduct while it prevails, giving you a better chance of escape than you otherwise would have.

Most all of the civilized nations, after having become convinced, through the accumulation of unmistakable historical statistics, of the enormous death-rates occurring from preventable diseases in an army in the field or wherever many persons are closely housed together, as well as of the great benefits derived from a knowledge on the part of the soldiery of "First Aid to the Injured," and the principles of hygiene, have caused such instructions to be made compulsory.

In Germany, England and France instruction in First Aid is given to the laity; thus it is estimated that during the year 1887 40,000 persons, men and women, received this instruction in Germany; during the same year, in England, over 100,0co persons

passed their examinations after having received the required instruction under the auspices of the great St. John's Ambulance Association, of which Capt. John Furley is the head. It is, no doubt, well known to you that the Red Cross Association is doing similar work in this country, and that thousands receive this instruction through the benevolent efforts of this truly grand association, annually.

For purposes of illustration allow me to cite a few instances which tend to show more clearly than this mere statement the wisdom of these measures. Right at the beginning of the war of 1870--71 between Germany and France, 30,000 men, on the German side, or one whole army corps, were suddenly disabled on account of their not having been supplied with proper shoe-gear, and consequently they were unable to take part in the first battles. Such a calamity might have been sufficient to turn victory into defeat.

One such instance is quite sufficient to show you the great importance of proper attention being paid to the hygiene of clothing during the movements of troops from place to place. Other instances might be quoted illustrating the same disastrous results with regard to insufficient and imperfect food supplies, poor or insufficient water, etc.

But the most striking figures, by far, we obtain from the records of the mortality from infectious diseases in the different campaigns. For instance, in the war of the Crimea the French troops, which were numerically the strongest, lost 20,240 men from arms and 70,375 from infectious diseases, a proportion of 1 : $3\frac{3}{4}$; the English troops lost 1761 through arms and 16,297 from disease, a proportion of 1 : 9; and the Russians lost 30,000 through arms and 600,000 through disease, or 1 : 20. In short, whole armies have been conquered and destroyed by the enemy disease before coming into actual contact with their enemy under arms, and the modern general of an army corps or admiral of a fleet can no longer disregard the practical value, the far-reaching importance of sanitary measures properly carried out and watched over by competent men. In the war just spoken of, if the mortality rate between the English and French troops is compared during the different periods of the war, the following most interesting results are obtained with regard to this point.

During the first winter the English lost 10,283 and the French

lost 10,934 from the same cause, although the latter were four times as numerous as the former. During the following winter, however, the English lost 551, while the French lost 21,182 men. Corresponding to the numerical strength of the armies, the French ought to have lost only four times as many as the English, but instead they lost forty times as many. Consequently the sanitary condition of the French army must have been ten times as bad as that of the English army. The question, now, was asked and discussed all over the civilized world as to how it came that such a discrepancy in the mortality rate occurred in two armies which were exposed to the same identical climatic conditions, inhabiting, as they did, the same land and moving side by side, both being supplied with equally good physicians and surgeons? The answer was easily found in the bitter complaints of French army surgeons of their inability to get their sanitary measures carried out, while the English surgeons were supported and supplied by their government, which spent fifteen millions of francs to enable them to carry out properly the measures which they recommended.

During our own civil war, it is estimated that the actual mortality in our armies from May 1861 to June 30, 1866, was 44,238 killed in battle and 260,131 that died from disease or the wounds received, after the battle. The enormous pension list which at present burdens this nation, although willingly borne by a grateful people, will never again assume its present gigantic proportions, if our army surgeons can carry out their present magnificent sanitary organization in the event of another war.

A great many appalling examples of bad hygiene and sanitary management might be cited from the records of our own wars, and are, no doubt, present in the minds of many survivors, for it is said, and with a good show of accuracy and truth, that since 1776, and although claiming to be a peaceful nation, we have lost more men in actual warfare than any nation of Europe. But the above few instances must suffice for our purpose, if otherwise we would not transgress the limits and scope of simply giving you some of the reasons for the dissemination among you of that knowledge without which no man, either educated or not, can possibly appreciate what sanitary suggestions mean, or have an idea of how to carry them into effect in the light of modern improvements. Nor does the necessity for giving this instruction to the officers and men in

our Navy grow less apparent on account of their number, which we all know is, comparatively speaking, limited. It would appear, on the contrary, that the smaller an army or navy, the more valuable is each individual life in it, and consequently the more economical ought we to be with the health and strength of each individual man. The people of the United States have all the more right to expect their army and navy to be a model of perfection in every respect and of their kind, as the numbers composing them are small.

New guns and new machinery have been invented for the destruction of human life; new ships are rapidly taking the place of the old ones; new drills and tactics have had to be devised to meet the requirements of modern warfare. Let us not forget to make preparations to succor the real motive power that works these modern fighting machines in times of need! Quite in keeping with the spirit of the second half of this nineteenth century, the most remarkable advances have been made in the treatment of wounds and diseases in general. In order to keep abreast with these modern advancements and improvements, it has become necessary in the Navy that the simple and always useless instruction of the men in the use of the tourniquet should be superseded by the introduction of a more systematic course of instruction in Hygiene and First Aid to the Injured. Without such knowledge on the part of the officers and men, the surgeon and sanitary officer is utterly unable in time of need to cope with the difficulties with which he is suddenly confronted, and the result of this condition of things can only be a repetition of all the disastrous occurrences, a few instances of which have been cited a little while ago and which time and bitter experience ought to have taught us how to avoid. "In times of peace, prepare for war."

The surgeons of the United States Navy, from whom alone this sort of instruction can come, so far as our Navy is concerned, find that they can no longer afford to overlook this part of their duty without some day incurring the just criticism and righteous indignation on the part of their government for culpable neglect of the trust at all times imposed upon them.

The surgeons attached to the different ships and shore-stations alone, however, would be utterly unable to do justice to their duties as they understand them without the commanders of these respective bodies of men having acquired an intelligent

appreciation of this part of their functions by proper instruction so as to aid their surgeons in carrying out their ideas. The men themselves will prove of the greatest assistance to the sanitary officer in his efforts to ward off infectious diseases among them, after having received the necessary instruction in these matters, giving them the reasons why certain things must be done. The work accomplished by our army medical officers is much admired and appreciated wherever it is known and well worthy of our imitation. So long as no one can tell us why the officers and men in the Navy should not receive the practical benefits of modern progress in medicine and surgery, the introduction of the systematic instruction of "First Aid to the Injured" should be encouraged and insisted upon by every officer having the welfare of the service at heart.

The general nature and causation of infectious diseases should be a subject familiar to every officer in the service. The times when typhus, dysentery, cholera, wound-fever, etc., carried off whole armies and paralyzed whole fleets, should never again recur in the future. A battle of Solferino, where the dead and dying lay for days and nights uncared for, and the heartrending description of which by Henry Dunant was the starting-point of the creation of the International Red Cross Association, ought to be sufficient argument for our cause as well.

The General Nature, Causation and Prevention of Infectious Diseases.

The fact that all infectious diseases are caused by what is called germs or bacteria seems so well established at the present day that there can be no further doubt in the matter. Bacteria produce disease principally in two ways, namely: (1) The germs find their way into the blood either directly, as through a wound, or indirectly, through mucous membranes, and finding all the conditions favorable to their growth and development they begin to multiply so rapidly that they soon become so numerous as to clog up the finer capillaries to such an extent as to render the circulation of the blood through them an utter impossibility. This form of causation is well illustrated in the eruptive fevers, as rose-rash, measles, scarlet fever, small pox, etc., in which the skin eruptions represent the small areas of interrupted capillary circulation. (2) The second method according to which bacteria

produce disease is that, instead of their bodily entering the circulation proper, they remain growing and multiplying at the seat of their primary inoculation, like a fungus on a tree, but produce a poison or toxine which is taken up by the blood-vessels and lymphatics and is thence carried to all the tissues of the body, causing the characteristic disease. This is the case in diphtheria, cholera, typhoid fever, and probably also yellow fever. The simple fact, so familiar to every one of us, and which is that certain individuals are particularly prone to catch a disease and die of it, while certain others do not, although exposed to its influence as much as those who contract the disease and die of it, proves beyond question that there are contained in the tissues and juices of our bodies substances that are able under certain conditions and circumstances to successfully antagonize the invasion of disease-producing micro-organisms.

The experimental study and investigation of the production of immunity against certain disease-producing micro-organisms form at present the most prominent of all the problems of biological research. A knowledge of the principles underlying these investigations is of such fundamental importance from so many points of view, and so well calculated to give you at once a comprehensive idea of the whole drift of modern medicine, that I have been tempted to give you at least an outline of one of these researches. The aim and object of them all is to finally teach us how and in what manner artificial immunity may be conferred upon any or all of us against any or all of the so-called infectious diseases.

The first question that arises is: What constitutes immunity against a disease, the cause of which, it has been proven beyond the question of a doubt, is a micro-organism? An animal is only, then, to be pronounced immune against a certain infectious disease when the particular disease-producing micro-organism is found to be incapable of undergoing multiplication in that animal's blood and other tissues or fluids.

About a year ago, the important discovery was made in Koch's laboratory at Berlin, by a young Japanese physician, Kitasato by name, that the blood-serum of certain animals, when added to fluids in which bacteria were cultivated, had an influence most decidedly antagonistic to their normal growth and development. In some cases it directly impaired their growth and multiplication; in others it would convert the previously poisonous germs into

harmless ones, though not preventing their actual growth. A large number of experiments were at once instituted in Germany, England, France and this country with regard to this point, resulting in the complete confirmation of the experiments of Kitasato. Thus it was found, in the course of these experiments, that it was more especially the blood-serum obtained from those of the animals which had proved themselves naturally immune from certain forms of infectious diseases, when injected into the blood of susceptible animals, would protect them against the disease.

There are substances floating in our bodies that are so extremely fine, so astonishingly subtle as to evade discovery even by the most refined methods of physiological research. The cleverest physiological chemist is as unsuccessful with the very finest of his reagents in catching and separating these finer elements of tissue-metamorphosis as the medical student would be over his dissecting table were he to endeavor to find, scalpel in hand, in the dead body in front of him the spirit of the departed.

It is and will ever remain the immortal merit of Dr. Robert Koch to have advanced and improved our modern methods of biological research, and all our advanced knowledge of disease in modern days is directly traceable to his work. In a recent number of Koch's journal (Zeitschrift fuer Hyg. und Infections-Krankheiten, Band XII, Heft II; Brieger, Kitasato und Wassermann) a most interesting and highly important set of experiments appeared in regard to a substance found in the bodies of all mammals and other vertebrate animals, having also exhibited to a most remarkable degree properties which are antagonistic to the growth and development of disease-producing micro-organisms. This substance is the thymus gland. It had long been suspected that this gland had some important function to perform with regard to the destruction of some of the products of waste, for, in cases of disease of this gland—in other words, whenever from any cause its normal functional integrity was impaired, a disease known as acro-megaly was produced, which is characterized by an abnormal accumulation in the subcutaneous cellular tissue of a substance called "mucin." This substance, a product of destructive tissue-metamorphosis, not being disposed of, accumulates in the system and thus produces this most characteristic disease. The particular bacterium to the growth of which the substance of the thymus gland has been found to be antagonistic

is the bacillus of tetanus (see fig. 1), a disease perhaps better known under the name of lock-jaw.

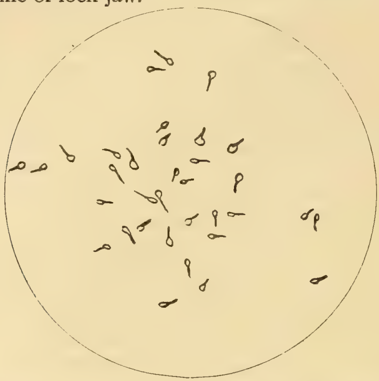


FIG. 1.—Represents the bacillus of tetanus, from a micro-photograph.

In going over the salient points of these experiments with you, the subject will become clear to you and at the same time will place you in the possession of a key by means of which you will be able to comprehend all the most important problems connected with the entire field of bacteriology and infectious diseases, as they will appear to you in your future readings from time to time.

In the first place you must know that tetanus or lock-jaw is a disease produced by a microbe which affects certain portions of the nervous system and is attended with convulsions that are almost invariably followed by death. The bacillus of tetanus is perhaps one of the best known of all the bacteria, because rather large and most characteristic; its morphology and physiology have been the object of study for many years past; the bacillus, so called because shaped like a rod, is often found in garden-earth somewhat below the surface; one of the ways of obtaining it, indeed, is to take some garden-earth and bury it underneath the skin of a mouse, sewing up the incision over it; the next morning the mouse will be found either dead or suffering from the effects of the disease; its liver, spleen, kidneys and heart-blood will be found to contain almost pure cultures of these tetanus bacilli. It is now easy to collect them, transplant them under proper precautions to their favorite culture-media and raise a large crop of them.

They flourish best when the inoculated test-tubes are kept in a culture-oven at a certain temperature. At the end of the first 24 hours' cultivation the culture is already so poisonous that a single drop of it would suffice to kill any animal living within from 20 to 24 hours.

Now the discovery has lately been made in the Berlin laboratory that, when some of these tetanus cultures were mixed with an infusion made from the thymus gland, the bacilli would grow and multiply the same as in normal culture-fluids, but fail to produce spores; in other words, the addition of thymus-infusion to these tetanus-cultures very materially interfered with their normal development and hence was antagonistic to that extent. The spores, it must be remembered, are the most dangerous parts of the bacilli. When, however, these sporeless bacilli were retransplanted on to more favorable soil, such as, for instance, grape-sugar-agar, the usual spores were again developed in the interior of these bacilli. Thymus-infusion, then, prevented the development of spores without entirely destroying their power of reproducing them.

With a mixture of thymus-infusion and a culture of tetanus-bacilli, the following experiments were now made on mice:

On October 6th, 1891:

Mouse	1	received	0.001	ccm.	subcutaneously,
"	2	"	0.01	"	"
"	3	"	0.1	"	"
"	4	"	0.2	"	"
"	5	"	0.5	"	"

Six rabbits were now taken and treated similarly; each rabbit received on alternate days gradually increasing doses of this attenuated thymus-tetanus-culture until each one bore a dose of 10 ccm. All these rabbits remained perfectly well, so did the mice.

Three of the above six rabbits were now taken and given each a deadly dose of an original and unmixed tetanus-culture subcutaneously; three fresh and unprepared rabbits received the same dose at the same time. The three last rabbits died within 24 hours; the three former ones remained perfectly well and showed absolutely no sign of disease.

It was now clear that those of the rabbits which had received the attenuated thymus-tetanus-culture had been rendered arti-

ficially immune against the disease, because on them full virulent tetanus-cultures produced no effect, while on rabbits not so prepared they had retained their deadly power.

Blood-serum of animals not susceptible to the disease having been previously shown to produce antagonistic properties when injected into the blood of susceptible animals, three of these protected animals were now bled, and from their blood the serum was prepared in the usual way. With this blood-serum four mice were treated as follows:

Mouse	1	received	0.5	ccm.
"	2	"	0.3	"
"	3	"	c.1	"
"	4	"	0.05	"

these quantities being injected directly into the peritoneal cavity. All four of these mice were well and alive 24 hours later, when each of them was given a deadly dose of full virulent culture of tetanus-bacilli and four fresh mice received the same deadly dose. The four fresh mice were all dead at the end of the next 24 hours; the four which had received the blood-serum from the protected animals remained perfectly well and were well 20 days after.

With this method Brieger, Kitasato and Wassermann were able to save 100 per cent of the animals; less favorable results were obtained with regard to cholera, diphtheria, typhoid and erysipelas.

Germs and their Relation to Wounds.

The great improvements which have taken place during the last fifteen years in the surgical treatment of wounds, having had their beginnings with the study and discovery of the life-histories and properties of germs or bacteria, I must use the remaining few minutes to make you still better acquainted with them. The three test-tubes which I now pass around contain cultures of three different kinds of bacteria on the ordinary beef-peptone-gelatine (see fig. 2); they were sent to me through the kindness of Dr. Philip S. Wales, of the Museum of Hygiene, and answer the purpose as well as any other to show you how we cultivate them in our laboratories.

Having proved themselves more deadly than guns and ammunition, the rôle which these germs play is of immense importance, and, unless I succeed right in the beginning to impress your minds with this fact, all the aid which you may hereafter be in a

Fig. 2.—Shows how bacteria are cultivated in test-tubes.

position to apply to any one must, necessarily, be of questionable value, faulty, or prove even hurtful and dangerous.

What, then, are these germs? Germs are the most minute microscopic, vegetable organisms in existence, infinitely smaller than the most minute particles of dust, and, unlike dust-particles, which are dead, they are living things, capable of almost indefinite multiplication in a comparatively short space of time. Multiplying as rapidly as they do, they consume a large quantity of food, and, on the other hand, throw out a great deal of new material. They lead the life of tramps, as it were; that is to say, they prefer to live on other creatures. The life-blood of animals seems to possess special attractions for them. A living animal, inoculated with certain kinds of these germs, may die within 24 hours. The germs, by their rapid multiplication, quickly consume the best and life's most sustaining constituents of the body, and leave in their places a changed fluid which proves poisonous to the animal organism, and consequently death follows in their track whenever they find entrance into the living organism, as, for instance, through a wound.

But, fortunately for us, a great many different kinds of these germs are perfectly harmless, some even useful; these, of course, having nothing to do with the causation of disease, do not interest us here. Nevertheless, it is well for you to know that germs are found most everywhere. They exist in the air we breathe, they are present in the water we drink, the soil we live upon and the food we eat; they infest our mouths, our noses, our bowels, and we carry them on our clothes. They are pretty well scattered all over the world, no portion of the globe being without them; they are found on mid-ocean as well as on the highest mountains. Of course, you will perhaps quite understand from this that most of them are, as was mentioned before, perfectly harmless. We breathe them in and out, we drink them in the water and we eat them with our food by the millions every day and no harm results. Indeed, they have been classified according to their properties into three great divisions: (1) those which produce contagious or infectious diseases, as for instance measles, scarlet fever, diphtheria, typhoid and typhus fevers, pneumonia, consumption, hydrophobia, small pox, chancroids, gonorrhoea, etc.; (2) the harmless ones; and (3) those which cause fermentation and decay.

All three kinds of bacteria, however, may produce death in more or less all animals, including mankind, when they accidentally

find entrance into the circulation direct, that is, through a wound. In other words, the same germs which, when swallowed with our food, remain perfectly harmless, when allowed to get into an open wound may cause death by blood-poisoning.

You will now, perhaps, more thoroughly realize and appreciate the fact than you did before, that it is owing to the invention and perfection of certain means and methods by which we manage to prevent the entrance of these germs into the wounds, that the great advances in modern surgical treatment have taken place, and to make you practically acquainted with some of these methods will be the object of the practical part of this first lesson.

Before, however, proceeding to the practical part of this lesson, allow me to call your attention right here at the beginning to something that you must not do under any circumstances. Every surgeon of experience has often had reasons to regret that the knowledge of the most simple little devices used in First Aid is an accomplishment so rarely met with among the people at large. Consequently many people lose their lives, not so much from the serious character of the injuries which they receive as from the fact that First Aid has been ignorantly and unintelligently applied. For instance, you may meet with a severe accident at any time and most anywhere in one of our crowded cities, on board ship, or in the field. Supposing it to be a fracture of the thigh-bone. You are unable to rise to your feet, you look pale, feel extremely weak and finally become unconscious. The people around you will almost instinctively try to do for you whatever in their opinion is the best thing to be done under the circumstances. Most likely they will try to stand you up on your feet and drag you to the nearest drug-store or down into the sick-bay, where, a few minutes after having been carried there, you give up the ghost and die. On examination, the fracture was discovered, and during transport the femoral artery was cut by one of the fragments and death was caused by loss of blood. Or, supposing the artery was left uninjured, one of the fragments has pierced the skin and amputation has become necessary when, under more favorable circumstances, you ought to have made a quick recovery with a useful limb.

Thus, as you see, your future usefulness, your health, your very life may, in that short space of time, be decided by the person coming to your aid and the manner after which he applies to you the first aid or help. In this manner many valuable lives have been

lost that might have been saved; limbs have had to be amputated and thrown away which ought to have been and would have been saved under more favorable circumstances. Therefore, you must always keep in mind the one thing you must not do, namely, Harm! Do no harm! Rather do nothing, whenever in doubt, than add insult to injury. Unless you feel sure you can do him some good, keep your hands off the injured man until some one arrives who knows better than you do what is best to be done.

Practical Exercises.

The materials used here are:

1. The ordinary operating table furnished to the ships of our Navy, covered with a clean white rubber-sheet and in perfect readiness for an aseptic operation.

2. Several buckets of clean water, soap and brushes; also several towels.

3. One tray with instruments under a solution of carbolic acid, strength 3 per cent.

4. One tray with a solution of corrosive sublimate, 1:1000, containing a few pieces of gauze.

5. Needles, cat-gut ligatures, safety pins, all in antiseptic solutions; iodoform-gauze and bandages for dressings.

6. Tray with alcohol.

7. Irrigator.

We will now suppose that an operation is to be performed requiring absolute surgical cleanliness. The walls, the floor and the ceiling of the room are supposed to have been thoroughly scrubbed and disinfected. Any dust in the atmosphere was removed by sending a spray of turpentine into it; the patient is now brought in, having previously received a bath and been provided with clean clothing; assistants and surgeon the same.

Having taken off his coat and put on a clean apron, the surgeon now begins to prepare his hands and forearms for the operation. He begins by cleaning his finger-nails, which are supposed to be the greatest harbingers of germs and are said to have been the cause of many premature deaths; the surgeon now rolls up his sleeves to the elbow and washes his hands and forearms with soap and water, using a brush in this manner, at the same time explaining as he proceeds that soap, water and the brush only remove ordinary dust and perspiration from the surface of the skin, but by no means are sufficient for the degree of cleanliness required

in an operation. Having done this, the hands must be dipped into alcohol for the purpose of removing the fatty particles adhering to the skin. Lastly, the solution of corrosive sublimate is used to kill any of the germs which still adhere or may fall on the arms and hands during his work. If there should happen to be any delay in the operation, the patient not being quite ready, the surgeon covers his hands with pieces of gauze soaked in the solution until the patient is ready to be operated upon. Every nurse and assistant must, of course, be prepared in the same manner.

The above described method was first devised by Fuerbringer and is the one in general use. Some time ago, however, Professor Wm. H. Welch, of the Johns Hopkins Hospital, proved very conclusively that this method could not be absolutely relied on. He made the important discovery that the skin, like the mouth and the intestines, besides bearing many different forms of bacteria on its surface, has quite a distinct bacterial fauna of its own which infests its very substance. Even after scrubbing the hands as has been described and demonstrated to you just now, Dr. Welch was still able to find living bacteria of a certain kind in the skin. The method of cleaning the hands, as recommended by him, based upon his researches and adopted at the Johns Hopkins Hospital, is as follows:

1. The nails are kept short and clean.

2. The hands are washed thoroughly for several minutes with soap and water, the water being as warm as can be comfortably borne and being frequently changed. A brush sterilized (made germ free) by steam is used. The excess of soap is washed off with water.

3. The hands are immersed from one to two minutes in a warm saturated solution of permanganate of potash and are rubbed over thoroughly with a sterilized swab.

4. They are then placed in a warm saturated solution of oxalic acid, where they remain until complete decolorization of the permanganate occurs.

5. They are then washed off with sterilized salt-solution or water.

6. They may then be immersed for two minutes in sublimate solution 1:500.

Every member of the class is now requested to practice on himself either of the above methods, and the objects of the first lecture, that of giving you an idea of the relation of germs to disease and that of impressing your minds with the importance of cleanliness in the treatment of wounds, will, doubtless, have been attained.

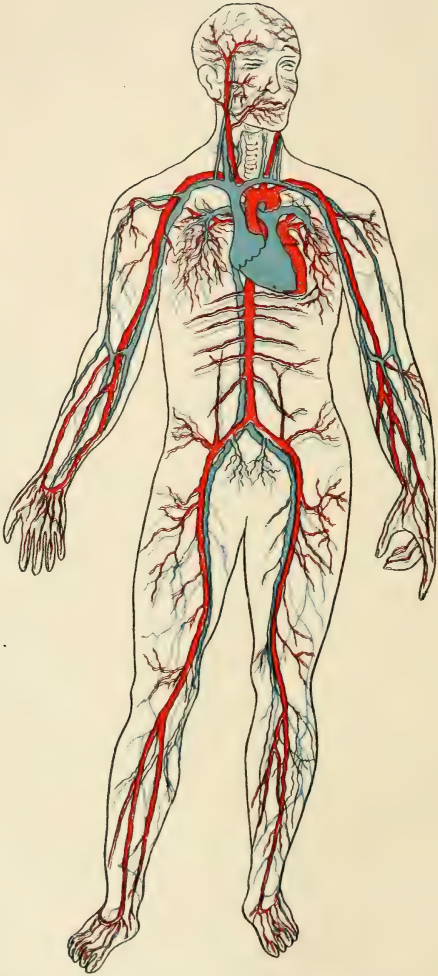


FIG. 4.—Shows the circulation of the blood and the large arteries and veins.

FIG. 3.—The human skeleton.

LECTURE II.

ANATOMY AND PHYSIOLOGY.

In to-day's lesson I shall tell you all you need to know about the different parts and organs of the human body, and what their respective functions are which they must perform in order to make life possible and to maintain it.

First, let me call your attention to the three pictures hanging up. One is a representation of a skeleton, that is, of all the solid parts of the body, put together just as they exist in the living subject. (See fig. 3.) The second represents, in a diagrammatic manner, the remaining parts of the human body, which I shall explain more in detail as we go along. The third picture is a very good diagrammatic representation of the circulation. (See fig. 4; also fig. *a*.) We will begin with

The Bones.—Without bones the human body would be a shapeless mass of flesh. The skeleton forms the solid basis or groundwork of the body and gives it shape and form. The bones, furthermore, protect the most important organs, such as the brain, spinal cord, heart, lungs and intestine, by throwing a protecting covering or lattice-work around these organs, so that slight injuries, at least, cannot possibly affect them.

The Head.—In the head we find twenty bones, most of them very irregular in shape, all very firmly united together with the exception of the lower jaw, which is attached to the base by a joint. The head may be divided into two parts, namely, the *skull*, which is a solid box containing and protecting the brain, and the *face*, in the solid framework of which are set up most of the organs of special sense, like so many precious jewels. The eyes, the ears, the nose and the tongue are all to be found about the face, lodged in very solid, protective recesses. They represent the terminations of the most highly specialized processes of the nervous system, and nature, therefore, has placed them so that they may, with ordinary care and in the ordinary walks of life, escape injury.

The Spine consists of twenty-four small, irregular shaped and rather complicated looking bones, placed one on top of another, and which are called vertebrae. These bones, when in position, form a sort of column, called the vertebral column, which forms the main support of the head and trunk. Being firmly held together by very strong bands, the spine can be moved and bent in various directions without displacing any of its component parts.

The Chest is formed of twelve ribs on each side, seven of which are called true ribs and five are called false ribs. Behind, these ribs are connected with the spine and are movable; in front they are more firmly united with the breast-bone and are immovable. The chest cavity contains the most important organs of circulation and respiration, namely, the heart and the lungs. Below, this cavity is closed in by a fan-shaped muscle, the diaphragm, which separates the heart and lungs from the stomach and intestine. (See fig. 16.)

The Basin, as you see on the diagram (fig. 3), is a very irregular shaped bony ring, giving strong support to the various intestinal organs, and also receiving the lower limbs into two large round sockets, one on each side.

The Limbs, in the human subject, are generally spoken of as upper and lower, or arms and legs. Each upper limb is composed of the collar-bone, the shoulder-plate, the upper arm-bone, the two bones of the forearm and the hand, which latter again is divided into the wrist (eight bones), the middle hand (five bones), and the fingers (fourteen bones). Each lower limb consists of the large and powerful thigh-bone, the two bones of the leg, one very much stronger than the other, and the foot, which is composed of twenty-six bones.

The Joints. (Figs. 5, 6 and 7.)—All the bones are firmly united to one another by very strong bands of a white fibrous tissue which, in the cases of some joints, completely surround their adjoining ends, thus forming a perfectly air-tight cavity. If you should cut open one of these joints (fig. 5), say the hip-joint, which is one of the most complicated of them all, you would be surprised, on putting your finger on the inside of it, how smooth everything feels. You would also notice a fluid partially filling the cavity of the joint, which is secreted by the lining membrane of the joint and is intended to lubricate it, so as to facilitate motion between the two ends of the bones.

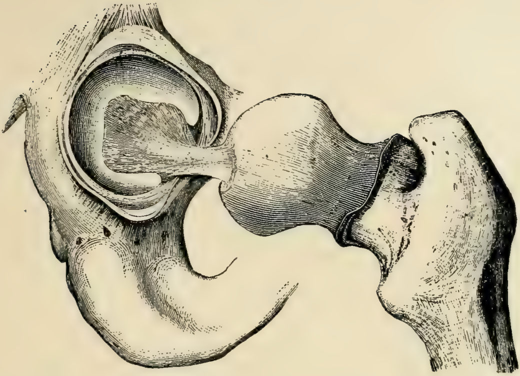


FIG. 5.—Shows the hip-joint laid open; the head of the femur attached to the acetabulum by the central ligament.

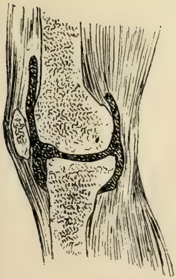


FIG. 6.—Longitudinal section of knee-joint.

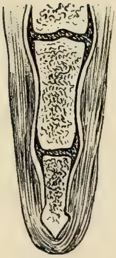


FIG. 7.—Finger-joints.

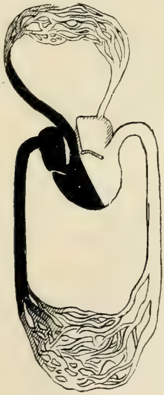


FIG. *a*.

FIG. 11.—Intended to represent the entire cerebro-spinal nervous system.

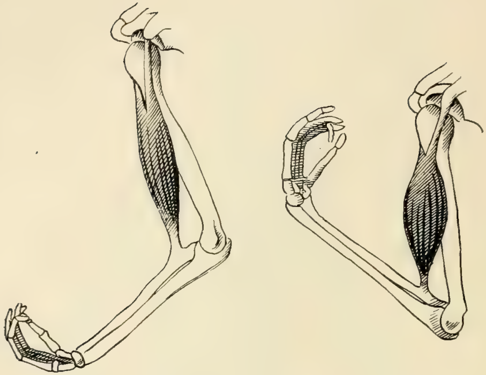


FIG. 9.—Shows the biceps in different stages of contraction.

FIG. 10.—Shows the brain in its relation to the skull and face.

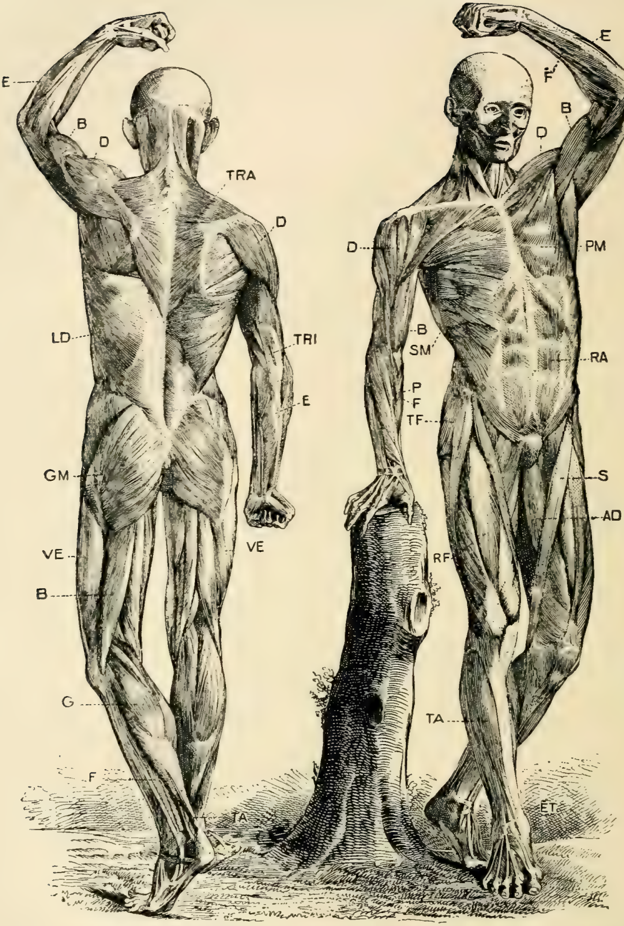


FIG. 8.—Shows most of the skeletal muscles of the human body, with initial letters of their anatomical names.

The Muscles (figs. 8 and 9) are the red masses of flesh which are distinguished from other soft parts not only by their color, but more especially by a very remarkable property; they possess, as you all well know, the power of contractility, best illustrated in the long muscles. (Examples, biceps, figure 9.) The sinews in which many of the long muscles end and by means of which they are attached to the bones which they are intended to move, are, on the contrary, not contractile, but rather unyielding. Muscular contractions may be controlled by the will, and then are called voluntary contractions; most of the skeletal muscles are of this kind. They may contract independently from any manifestations of our will power, and those contractions are called involuntary contractions, the muscles themselves being called involuntary muscles. The muscles of most of the viscera, such as the heart, lungs, stomach and intestines, are of this kind.

The Nervous System, (see figs. 10 and 11), of all other systems, is the most important, the most wonderful and the most complicated. It is divided into the brain, spinal cord and nerves. The brain presides over all the functions necessary for the maintenance of human life. It is the seat of consciousness; it directs the beating of the heart, the digestion of food; it is through it that we see, hear, smell, taste and feel. Without it, the human mechanism would be a most complicated machine, without a superintending engineer and without motion or sensation. This organ is situated in a very firm, bony case, and is thus protected by nature in accordance with its importance. Injury to the brain means unconsciousness, paralysis of all the muscles of motion, of sensation and speech. The spinal cord is a long, cylindrical cord of nervous tissue contained in the spinal canal, and sending out thirty-one pairs of nerves through small openings in the bones composing the canal. These nerves go to all parts of the body, carrying the various impulses of motion and endowing them with general sensation. Injuries to the spinal cord mean paralysis of motion, and also perhaps sensation, of all the parts below the seat of the injury.

Both brain, spinal cord and nerves are made up of numerous fine fibers and an endless number of cells or pyramidal-shaped minute little bodies. Nerve force is generated in the cells, and the fine fibers which the latter send out in all directions serve the purpose of conductors of whatever energy may be evolved by the particular group of cells with which they happen to be connected. Thus, the spinal cord, which is in direct connection with the brain,

sends into the brain a large number of fibers, and in this way forms really a combination of the brain with all the other organs and tissues, including the skin; just as the queue of a Chinaman is merely the gathered up and braided mass of hair coming from and spreading out all over the hairy scalp, so is the spinal cord only the braided mass of fine nerve fibers coming from the brain and going through the cord into the tissues at large.

Circulation.—Before speaking of the circulation, I will first explain the colored diagram which you see before you (figs. 4 and *a*). In the center of the picture you see the heart; the left side is painted a bright scarlet red, and the right side of a blue color. You will also see that all those vessels connected with the left side of the heart are, like that side of the heart itself, of a bright red color, and that all the vessels connected with the right side of the heart also present its color, which is blue.

The red fluid which flows in every variety of organ and tissue in our bodies, and which must flow to keep them alive and functional, is the blood. The blood is kept in constant circulation through a most wonderful piece of apparatus, the heart and a very complicated system of tubes, the arteries, capillaries and veins. The heart (see fig. 12) is a muscular sac, having a number of openings provided with valves. When it contracts, it forces out all its contents in a certain definite direction, owing to the disposition of these valves, and when it expands, it admits a new lot of blood, owing to the same cause. The action of a Davidson syringe (figs. 13 and 14), which you see here, is no mean illustration of this pump action of the heart. But, unlike a Davidson syringe, which has but one cavity; the cavity of the heart is divided into four compartments, two for the right side and two for the left side of the heart. The blood, as you may see on the diagram, is then contained in a closed system of tubes, of which the heart forms the central propelling organ or motor power. We will now follow the blood from the left lower chamber of the heart in its course back to the same compartment. It leaves this chamber by a very large blood-vessel which quickly breaks up into smaller and smaller ones, which finally terminate in such fine little tubes that they can only be seen with the microscope. Those tubes, or vessels, which are thus directly connected with the left side of the heart, leading the blood away from the heart, containing bright red, aerated or purified blood, are the arteries. In these vessels you may feel

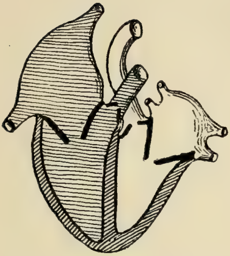


FIG. 12.—Diagrammatic representation of the valves of the heart.

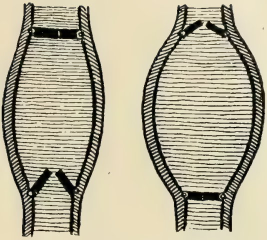


FIG. 13.—Shows valves inside of rubber bulb of a Davidson's syringe.

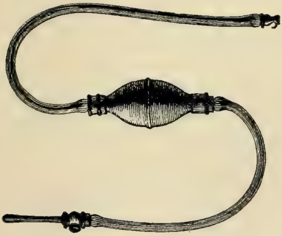


FIG. 14.—Davidson's syringe.

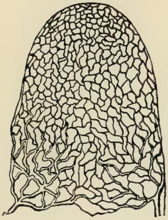


FIG. 15.—Shows an artery breaking up into capillaries on one side and the beginnings of a vein on the other.

the heart's impulse when you place your finger lightly over their course. The very fine, hair-like vessels which these arteries finally terminate in, are called capillaries (fig. 15). Every tissue and organ of our bodies is as completely and thoroughly permeated with these capillaries as are the meshes of a sponge holding water. The slight amount of bleeding noticed in a superficial abrasion is due to the wounding of these minute, microscopical tubes; they reach so very near the surface of our skin that but a few layers of scales separate them from the outer world. (Ex. Pressing on our skin leaves a white mark.) It is here, however, where the blood comes in contact with those tissues which it is intended to nourish and where it performs its most important functions; the largest tubes are merely the channels for conducting the blood to this most important system of capillaries. It is here that the blood gives up its oxygen and receives carbon dioxide in its place. It is here, also, where the bright scarlet color of the blood is changed to a very dark red, almost black color, in consequence of the lost oxygen and the absorption of CO_2. From the venous side of the capillaries this blood, which must be refreshened, as it were, is collected again by a different system of vessels, called veins, which now carry this dark, almost black blood back, as you see on the diagram, to the upper chamber of the right heart; hence it is pushed on into the lower or larger chamber of the right heart, from whence it is finally pushed on in a very large blood-vessel into the lungs, where the vessels again break up into capillaries. In these capillaries which penetrate the lungs you will notice that the dark blood is changed again into bright red blood. While in one set of capillaries it lost its oxygen and received carbon dioxide, in the capillaries of the lung the very contrary takes place, namely, the blood loses its carbon dioxide and receives new oxygen. This purified blood is taken up by a few larger vessels and conducted into the upper chamber of the left heart, whence it is propelled on into the lower chamber of the left heart, whence we started in our description. One such turn is called a revolution; the blood makes about two such revolutions in a minute.

From these remarks and by the help of this picture you will have gathered that in a wound filled with bright red blood arteries must have been wounded, and on the other hand, dark blood would indicate that veins were wounded. The former injuries

must be naturally the more serious, as arteries run much deeper than the veins, and more blood is lost through arteries in a given time than through veins, on account of the higher pressure which exists in the arteries.

It was necessary for me to dwell a little more at length on the subject of the circulation of the blood on account of its great importance, which you will be better enabled to appreciate when we come to speak of the application of the tourniquet and other means for arresting bleeding.

The Lungs (fig. 16) are two large masses of spongy tissue contained in the chest cavity and serve the purpose of aërating the blood. The air is made to enter the large tube which is easily felt in front of the neck, also called the wind-pipe, and which branches out, tree fashion, into a large number of finer twigs, finally terminating in very small vesicles or expansions. These bladder-like vesicles are completely covered over with a very fine network of blood-vessels, the very capillaries carrying venous blood and wanting to give off their CO_2 and receive oxygen in its stead, and which I have been speaking to you about under the head of the circulation. Without this important organ life is impossible. (Example: Tying the trachea of a dog. Mouse under a bell-jar.)

The Kidneys (fig. 17) are two large, bean-shaped bodies, situated in the abdominal cavity, in front of and to the side of the spinal column. They are connected with the bladder by the ureters, two large tubes carrying the urine which the kidneys secrete into it. They also are very essential to life, and their diseased condition gives rise to what is called Bright's Disease. Urine, which they secrete, is a solution of a solid substance, urea, and which must, like carbon dioxide, be gotten rid of, otherwise it would poison the blood.

The large sheet of skin (fig. 18) which covers our bodies does not only prevent the soft parts from drying up, but also throws out substances in the perspiration which if retained would poison our blood. The three millions of sweat glands are actively engaged in this work, especially so in hot weather. Nourishment, of course, must supply this constant wear and tear going on within us. We are all familiar with the process of eating and drinking (see figs. 19 and 20). Digestion begins in the mouth, where the food is ground up by the teeth and thoroughly mixed with the alkaline saliva. The resulting paste is passed on through a long muscular tube into the

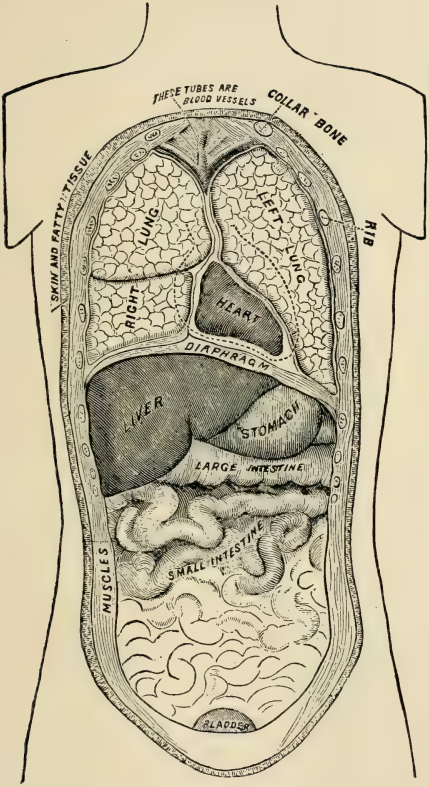


FIG. 16.—Shows all the viscera in position and their relation to one another.

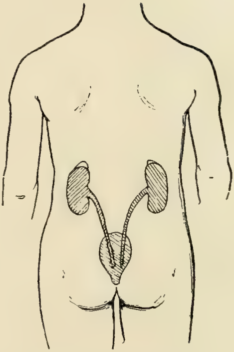


FIG. 17.—Showing kidneys, ureters and bladder.

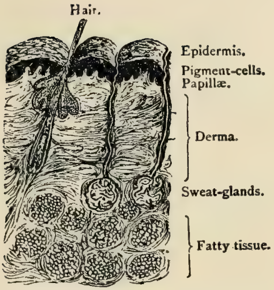


FIG. 18.—Vertical section of skin.

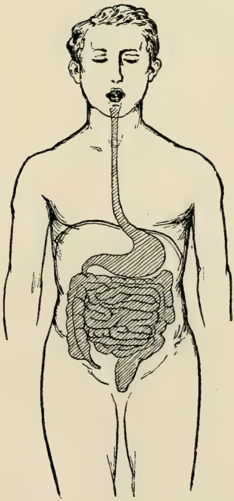


FIG. 19.—Shows stomach-tube, stomach and intestine.

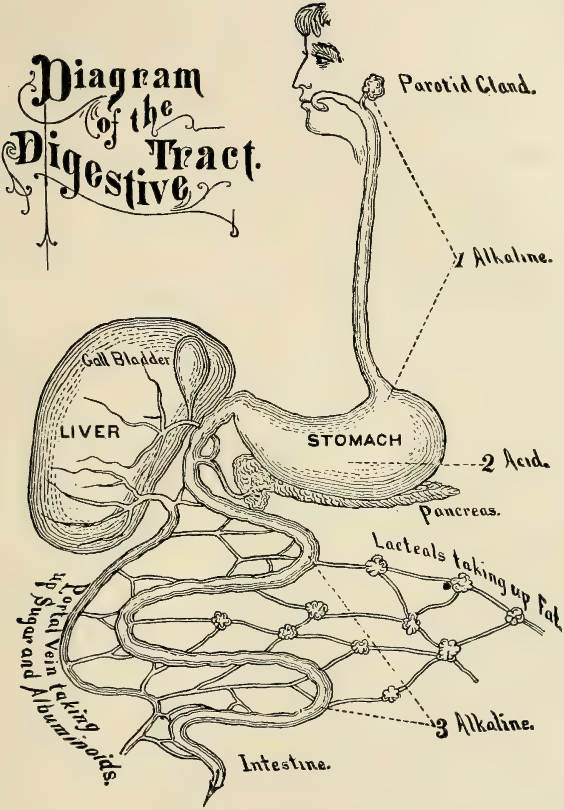


FIG. 20.—Diagram showing the digestion of food and how the food is exposed alternately to the action of alkaline, acid and again alkaline fluids secreted by the different portions of the alimentary canal.

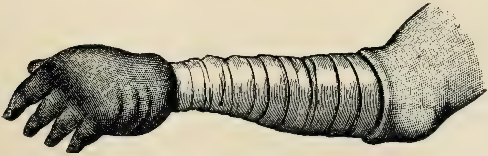


FIG. 21.—Shows results of bad bandaging.

stomach, where the food remains a while, undergoing further acid digestion. From the stomach it passes into the small intestine, where the bile manufactured by the liver helps to prepare it for final absorption and use in the economy at large.

We will now pass on to the practical part of this lesson, which to-day will consist in the application of Esmarch's triangular and quadrangular bandages.

Bandaging.—As first-aid-men, allow me to urge upon you the prime necessity for acquiring a thorough knowledge of the art of bandaging. Do not permit yourselves to look upon this part of your work as of minor importance, simply because it has been relegated to what is called "minor surgery." The subject is an important one, and large prizes have been awarded in the past for essays and treatises on bandaging. There is perhaps no one single thing by which one can so well and so readily distinguish a superior nurse from an inferior one as by watching the manner after which he or she puts on a bandage, and if you should ever be so unfortunate as to become a patient yourself, the difference between a good and a bad bandagist would, no doubt, be indelibly engraved upon your mind.

The proper knowledge of bandaging can, very naturally, be acquired only by practice, and what I have to say here on this subject will only relate to some of the more important principles underlying the art of *good* bandaging.

In applying a roller bandage to any part of the body or any of the limbs, you must remember first of all that it should exert an even pressure in every turn throughout its whole length. Secondly, after applying a rather tight dressing or bandage to any part of the arm or leg, a supporting bandage must be put on that part of the limb from the hand or foot respectively up to the place where that dressing or bandage is, otherwise swelling of the part below the dressing will ensue (see fig. 21). The reason for this is simple enough when you recall to your minds your lesson on the circulation of the blood. A tight bandage will compress the veins and in this way impede the return-flow of the blood.

For roller bandages three kinds of material are used, namely: (1) Calicot. (2) Starched gauze bandages, which latter are put into hot water for about a minute before being used, then pressed out and applied. Being somewhat sticky, they are pliable and more apt to stay better than dry ones, and, after drying, form a pretty firm envelope of the part to which they were applied; they

make excellent head-bandages on account of their staying qualities. (3) Muslin bandages are found in all lengths and breadths and can be smoothly applied to all parts of the body. The technique of their application will be shown in the practical exercises that will follow.

Some years ago a so-called "wound-package" was proposed by Prof. v. Esmarch, intended to be carried by every soldier in the field. This package has done great service in the last Franco-German war and also in the wars of the English against the Boors, in Ashantee, Egypt and the Caucasus. This little package contains a triangular bandage, two small pieces of sublimate gauze to be used as compresses, and a gauze bandage four inches broad and six feet long. The whole is well packed and wrapped up in water-proof material, about four inches square and not weighing over three and a half ounces.

In cases of simple gunshot wounds (see fig. 22), one of these gauze compresses is placed over the wounded part after removing the water-proof wrapper. In cases of large wounds, the gauze compresses are unfolded so as to cover the entire exposed surface with them. The bandage (roller) is then applied over the gauze compresses to keep them in place, and the triangular bandage is used for the further protection of the wound, for purposes of support of the wounded member or for tying on splints.

The package may be worn on most any part of the lining of a soldier's or sailor's uniform.

The triangular cloth bandage has become one of the most generally used bandages in first aid. The bandage ought to measure at its base about 60 inches, its height to the tip or point ought to be thirty inches. In its simplest manner it is applied folded together after the manner of a neckerchief. Figs. 23 and 24 show how it is applied to the hand and foot, and fig. 22 shows how it is used over the dressing of a wound. In tying the ends together use the sailor's knot, not the false knot, as shown in figs. 25 and 26. In order to cover the entire hand and foot, the bandage is spread out; the base of it is placed at right angles to the long axis of the part to be covered in, its tip is carried around the part, then the two remaining ends of the bandage are crossed in front of the point, wound around the limb and tied at the most convenient place. See figs. 27 and 28.

When it is to be applied to the head (fig. 29), lay its base across

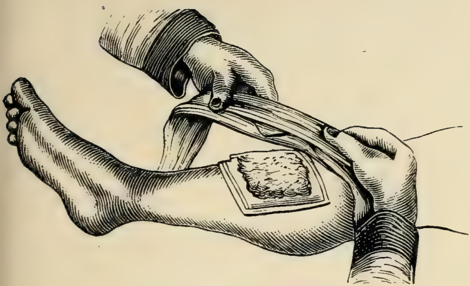


FIG. 22.—Shows how to dress a simple wound.

FIG. 24.—The triangular bandage applied to foot.

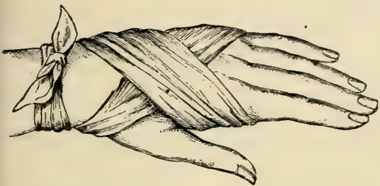


FIG. 23.—The triangular bandage applied to hand.

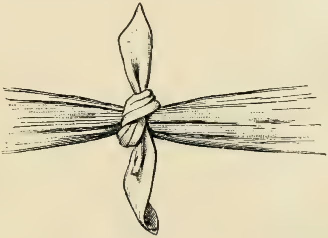


FIG. 25.—False knot.

FIG. 26.—Sailor's knot.

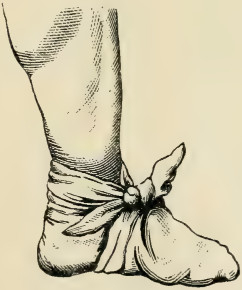


FIG. 27.—Bandage applied to foot unfolded.

FIG. 29.—Triangular bandage applied to head.

FIG. 28.—Bandage applied to hand unfolded.

FIG. 30.—Triangular bandage applied to chest.

FIG. 32.—Triangular bandage applied to hand, elbow and shoulder, with small arm-sling.

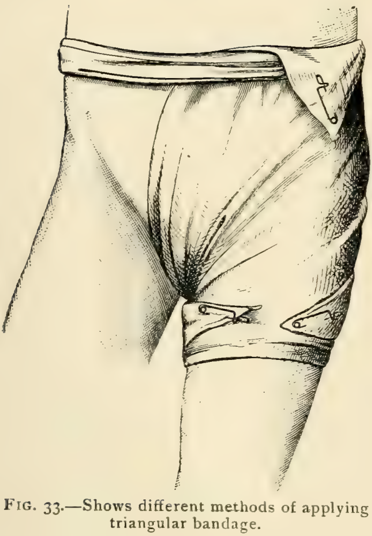


FIG. 33.—Shows different methods of applying triangular bandage.

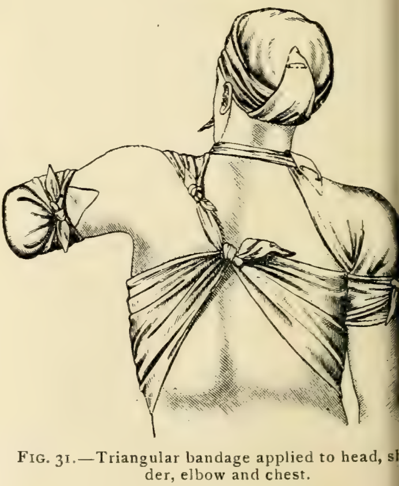


FIG. 31.—Triangular bandage applied to head, sh[oul]der, elbow and chest.

the forehead near the eyebrows, turn the cloth over the top of the head, its point hanging down over the back of the neck; now take the two corners, carry them to the back of the head above the ears, there cross them and bring them back, tying them together over the forehead; lastly, take up the tip end, pull it up over the head and secure it with a safety pin as shown in fig. 29. In this manner wounds on almost any part of the head can be covered.

In wounds about the chest, after proper treatment by disinfection and tying over them the gauze compresses with the roller bandage, the triangular bandage is placed over the chest with the point over one of the shoulders, whichever seems the most convenient, the two ends carried around the chest and there knotted; the point is secured to one of the other ends as represented in figs. 30 and 31.

In wounds of the shoulder, lay the center of the bandage on the top of the arms, with the point up the side of the neck, the lower border lying at right angles to and at about the middle of the arm; carry the two extreme ends around on the inside of the arm, cross them, bring them back on the outside and tie them there. Fold a second bandage and make a small arm-sling of it, then draw the point of the shoulder bandage under the sling, fold it back on itself and fasten with a safety pin on top of the arm. See figs. 31 and 32.

In wounds of the upper arm, place the center of a broad-folded bandage on the front of the limb, carry the ends round to the opposite side, cross them, bring them back and tie them together. Next make a small arm-sling as follows: take a second broad-folded bandage, throw one end over the shoulder on the wounded side, carry it around the neck so as to make it visible on the opposite side, then bind the arm carefully and carry the wrist across the middle of the bandage hanging down in front of the chest; this done, take the lower end over the shoulder on the sound side and knot the two ends together at the nape of the neck. In wounds of the forearm, bandage the wound as in the preceding case, then make a broad arm-sling as follows: take a second bandage, throw one end over the shoulder of the sound side and carry it around the back of the neck, so as to make it appear on the opposite side, where it is to be held fast. Place the point of the bandage behind the elbow of the injured arm and draw down the other end in front of the patient's chest. Next place the arm across the chest over the middle of the cloth, then pick up the

lower end, carry it upwards to the shoulder on the wounded side where it meets the upper end and the two may be tied together; the point may now be drawn forward around the elbow and pinned. Figs. 35, 36 and 37.

The method of applying this bandage to wounds of the thigh, knee, leg and other parts may easily be inferred from the foregoing. See figs. 33, 35, 36, 37.

A very practical and useful bandage, also, is the quadrangular bandage of Esmarch, which, as very well shown in figs. 38 and 39, may be made to be used as a protection for the head and a good part of the neck. In size it is about one meter square. Before applying it, fold it so that the broad margin of one half of the cloth projects about four inches from below the other half; in this way put it over the patient's head so that the middle line of the bandage comes to lie over that of the head, the narrow lateral margins being allowed to fall over the sides of the neck and shoulders. Adjust it so that the lower border of the under layer just covers the tip end of the nose, and that of the upper layer is in line with the eyebrows (fig. 38). Of the four corners now hanging down in front of the neck and upper part of the chest, take the two outer ones and tie them fast to the chin and underneath it; the two inner corners are pulled out, the border covering the nose is folded up over the forehead, and the two corners are carried back over the ears and tied behind (fig. 39).

This bandage, like the triangular one, may also in some special cases be used for making a sling (fig. 34). In rough weather the quadrangular bandage is a most useful one.

In general terms, the triangular and quadrangular bandages may be said to serve the following purposes:

1. As a protection of the parts from dust, heat, cold and insects.

2. To exert a certain pressure over bleeding surfaces, so as to aid in arresting hemorrhage.

3. To keep the injured parts at rest and for the securing of splints.

Another very convenient bandage, easily applied to the head, is the four-tailed bandage (fig. 40). This consists of a piece of muslin thirty inches long by seven wide, slit from both of its ends to within three inches of the center. In order to fix a dressing on the top of the head, lay the center of the bandage over it. Tie the two front ends at the nape of the neck and the two back ends under the

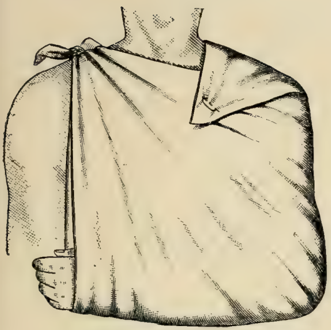


FIG. 34.—Shows quadrangular bandage used as a large arm-sling.

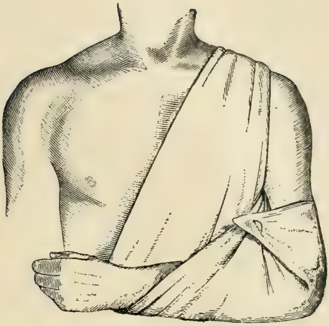


FIG. 35.—Shows different methods of applying triangular bandage.

FIG. 36.—Shows different methods of applying triangular bandage.

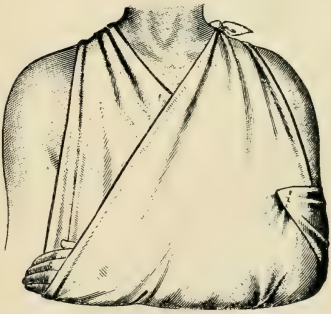


FIG. 37.—Shows different methods of applying triangular bandage.

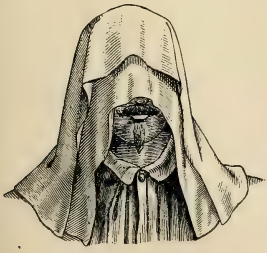


FIG. 38.—Shows quadrangular bandage folded and placed over the head.

FIG. 39.—Shows quadrangular bandage properly applied.

FIG. 40.—Shows how to apply the four-tailed bandage.

chin. To keep a dressing on the back of the head, tie the front ends under the chin and the back ends over the forehead.

The four-tailed bandage may also be applied to the jaw, but then it only needs a width of three inches. Slit the ends so that four equally long ends are produced, leaving an unslit portion in the center about three inches long. In the center of this portion cut a hole for the chin. Place the chin into this, carry the lower two of the four tails upwards and tie them on top of the head, and finish by tying the upper two tails at the back of the neck. Fig. *b* shows bandage applied to eye.

Practical exercises: Bandaging.

FIG. *b*.

LECTURE III.

INJURIES OF THE SOFT PARTS.

The injuries which we are liable to meet with vary much in nature and in gravity. A slight hurt, such as a blow from a man's fist applied to most any part of the body, is hardly ever very dangerous in its consequences and, therefore, needs scarcely any medical attention. An injury inflicted by means of a sharp instrument, resulting in an open wound, though this wound is not very deep, is already a much more serious injury, requiring skilled surgical treatment. If the instrument, which may be a knife, spear, sword or dagger, has penetrated into the cavities of the body in which are contained the heart, lungs, liver, stomach, intestine and bladder, the most serious results may be expected. In such injuries still greater care and skill are required by the attendant than in any of the above-mentioned examples.

The most serious of all injuries, however, are the so-called gunshot injuries produced by missiles that are propelled by some kind of explosive material, and the treatment of which calls for the greatest possible degree of skill and judgment on the part of the surgeon. Gunshot injuries, as a rule, involve both the soft and hard parts of our bodies, giving rise not only to very serious penetrating wounds, but also to fractures and dislocations.

Injuries, as you may see, differ in many ways: they differ in accordance with the particular place to which the external violence causing the injury is applied; they differ with the kind of instrument producing the injury; they differ with the nature of the external violence, and so on.

For our present purpose it will be found both convenient and advantageous if we divide all injuries into two great classes, namely: (1) Those of the *soft* parts and (2) those of the *hard* parts of our bodies. In this lecture we will confine our attention to the consideration of the *injuries* to the soft parts, and likewise divide them for convenience sake into two classes, namely: (1) CONTUSIONS and (2) WOUNDS.

1.—Contusions.

The large sheet of skin, covering our bodies, possesses to a high degree the properties of distensibility and elasticity. It is owing to these two properties combined that injuries of the deeper parts are possible without any material injury being at the same time done to the skin itself, and giving rise to what is known as contusions.

Wherever we may be struck by some blunt instrument, the skin, owing to its elasticity, will yield to the pressure, temporarily exerted on it, and so escape injury. It is different with the more delicate tissues which lie beneath the skin, namely, the small arteries, veins and nerves; these are generally ruptured, the arteries and veins pouring their contents into the artificially formed spaces caused by the injury beneath the skin and their neighborhood. If the amount of blood which has escaped is small, then a slight discoloration of the skin will be the only noticeable result of the injury. When, however, the violence producing the injury was considerable and directed to a place where there is a great deal of loose cellular subcutaneous tissue, then the effusion of blood will be correspondingly large and will give rise to what is known as a *blood-boil.* We will then have a more or less distinct and poorly circumscribed swelling, easily yielding to pressure, covered by a much discolored skin, and in which fluctuation may easily be detected, owing to the fact that not all the effused blood undergoes coagulation, some of it remaining fluid.

If the injury occurred to a certain part of the body which is richly supplied with lymph-vessels, the result would be a rupture of these and an effusion of lymph with comparatively little blood. The resulting tumor would be much cleaner looking on account of the lack of discoloration; it would also be much larger and present much greater fluctuation.

Blood, having once left the blood-vessels, does not again return as such into the general circulation; it coagulates after a short while, the coagulum degenerates and the resulting fluid is taken up and absorbed by the lymph-vessels. The length of time which this process occupies, of course, depends on the amount of blood to be absorbed; absorption is, as a rule, very slow, as may be inferred from the time it takes for the discoloration to disappear. The discoloration of the integument, due to the absorption of the

escaped blood pigment, passes from a bluish-brown to a green and light yellow and then disappears without leaving a trace.

The degree of pain felt after a contusion depends on the amount of injury done to the nerve-twigs of that neighborhood.

Sprains, so called, present a similar condition of things, although not commonly classed under the head of contusions and most generally understood as injuries involving joints. Nevertheless we find that sprains, like contusions, are accompanied by swelling and pain, owing to the effusion of blood or lymph and the rupture of the finer nerve-twigs at the seat of the injury. The ligaments about the joint may be overstretched or torn completely across, owing to the forcible separation of the bones forming the joint incident to the injury received. The amount of swelling accompanying such an injury to a joint is usually very great, the skin glistens and feels hot, the usual bony prominences have disappeared, and the pain is very severe and on the increase. To the touch, the swelling conveys the impression of a soft, jelly-like mass situated beneath the skin, consisting, as it does, of a coagulum of blood and lymph mixed together.

On account of the local disturbance in the circulation, consequent upon the rupture of blood- and lymph-vessels, collateral circulation and increased transudation of blood-serum through the distended and partly paralysed coats of the blood-vessels must take place, which still further increases the affected swollen and oedematous area. Local inflammation and slight general fever will be found not infrequently complicating such cases.

The treatment of the injuries described so far must differ in accordance with the length of time that was allowed to elapse from the moment the injury occurred to the time when the first help was administered. In case several hours have elapsed and the pain and swelling greatly increased, all that you can do is to place the limb at rest, slightly elevating it and making cold applications with either water or ice. If, however, you should happen to be on the spot but a short time after the occurrence of the injury, then massage the part without further hesitation. The influence of massage on these injuries is twofold: (1) It allays the pain, although, perhaps, itself somewhat painful in the beginning. (2) It initiates and accelerates the otherwise long and tedious process of the absorption of the effused blood and lymph, in this manner shortening the duration of the healing process and thus

restoring the parts to their usefulness in a much shorter space of time than when left to themselves. Massage consists in a number of peculiar mechanical manipulations of the injured parts, all carried out by the hands and fingers of the attendant, such as rubbing, pressing and beating. In fresh injuries gentle rubbing alone is admissible, and this must always be done in the direction from the periphery towards the center. In order to facilitate the gliding of the hand over the parts and also to prevent injuring the skin, the parts must first be oiled. Let us take, for example, a fresh sprain of the wrist-joint which is fit for massage. You would grasp the fingers of the injured extremity with your left hand and pull them slightly away from the wrist; then, with the right hand, after oiling the back of the hand, wrist and part of the forearm, you would begin by making at first very gentle and slow movements with the flat of your hand or the palmar surfaces of your fingers, and carry them up to about the middle of the forearm of your patient; there you take off your hand and go back to whence you started, and so on. Very soon the severe initial pain will cease and now you will apply a little more pressure; after a little while, turn over your patient's hand and treat the other side in the same manner. In this way you may continue for from 20 to 30 minutes at a time, repeating the process whenever necessary. Remember, however, that both in the beginning and towards the end of the massage the pressure to be applied must be of the gentlest kind.

The object of the massage is to cause a quick return of the effused blood and lymph into the circulation through the lymph-vessels, hence also the necessity of rubbing in the direction of the course of these vessels, that is, from the periphery towards the center. After the massage the injured parts are to be covered with wet compresses and a bandage. Under this treatment a sprained wrist or ankle will get well in a few days, while under the delayed treatment as many weeks may pass by.

There is still another class of injuries, occurring now and then, in which the skin also remains unbroken, but with much more serious injury done to the deeper parts than the mere rupture of blood-vessels and lymphatics, and which we must consider here. The ligaments and capsules of joints, tendons and muscles are frequently torn by certain kinds of direct or indirect violence without the skin being broken; but the most serious complications of

contusions, by far, must be looked for in injuries involving the head, chest and abdomen. In blows upon the head that are not sufficient to either cut the skin or fracture the skull, the brain may receive such a shaking-up as to give rise to a temporary paralysis of the brain-centers, including the vaso-motor-centers. The face of the injured person suddenly becomes very pale, his limbs feel cold and his temperature falls below the normal. There is loss of consciousness and general sensation, the patient lying perfectly motionless on the ground; his eyes are closed, the pupils widely dilated and not reacting to light. Breathing is frequent, feeble and shallow; the pulse frequent, feeble and fluttering, sometimes almost imperceptible. There may be vomiting and involuntary evacuations taking place from the bladder and rectum.

Symptoms of paralysis and convulsive twitchings, however, are not part of the symptoms of mere concussion of the brain. If you should find such symptoms present, about the face or any of the extremities, then the case ceases to be one of concussion of the brain and will prove to be one of more profound injury to the brain, for paralysis is a symptom of compression of the organ; the compressing agent may be either blood or a fragment of the fractured skull.

In concussion of the brain the symptoms that present themselves are not unlike those that occur in an ordinary fainting-fit; in both cases we have to deal with a condition of anaemia of the brain. An uncomplicated case of concussion may last from several minutes to so many days, but is seldom followed by death, and when it is the concussion will always be found, on post-mortem, to be associated with more serious injury, perhaps laceration of the brain-substance.

First Aid in such cases consists in placing your patient in a horizontal position *with the head low!* To raise the body or even the head under such circumstances would mean *harm*, not *aid;* it would retard the return of consciousness directly. Next, you must take off your patient's clothes and cover him up with warm blankets or, better, warm bottles; as soon as consciousness returns, give him some warm tea or a very small quantity of brandy; the head is to be covered with cold compresses, for the reason that, in the reaction which follows the condition of anaemia of the brain and which consists in congestion of the organ, cold is the only remedy that can be safely applied to counteract it or prevent it

from being too violent. In watching the patient closely and carefully you will observe this reaction to occur in the face, the extremities and the whole body; the entire surface becomes gradually warm and red. In case this reaction is unduly delayed you may be called upon to bring it about reflexly by holding some strong-smelling substances under his nose, such as ammonia, or by sprinkling cold water into his face, also giving him a cold enema of vinegar; if, however, on the contrary, the reaction is prompt, then remember that *rest* is what your patient most needs, and you should do all in your power to keep every body and every thing away from him that will interfere with his rest. Rest and fresh air will now do all that remains to be done.

Concussion of the brain is, furthermore, frequently associated with concussion of the spinal cord, as is well shown by the pallor and decreased sensibility of the skin, as well as by its coldness. A case of concussion of the cord, pure and simple, passes off without leaving a trace; any symptoms of paralysis or convulsive movements on the return of consciousness, or any involuntary evacuations from the bowels or bladder, or the presence of areas of lost general sensibility with subjective pains in the parts or paralysis, would indicate injury to the substance of the cord itself by pressure or otherwise. The result of such an injury is always a sad one, and all you can do for it as first-aid-men is to secure for your patient as comfortable as possible a position and perhaps place ice over the spine.

Shock, so called, is the result of a concussion of the *sympathetic nervous system* (fig. 41). A sudden fright, a fall, a blow on the stomach, injuries involving the complete loss of an entire limb, received suddenly, large and extensive burns, may be followed by shock. The patient is usually pulseless, pale, with a changed facial expression, deep blue rings about the eyes, covered with cold perspiration, vomits frequently and complains of great thirst. In some of these cases the diagnosis may be difficult and even impossible. In the more serious cases, those that are complicated with severe injury to the internal organs, the best that can be expected of you is:

1. That you send immediately for a physician.

2. That you loosen all tight clothing or take them off altogether, according to the circumstances of the case.

3. That you place the injured person in a comfortable position, allowing no one to handle it until the physician arrives.

4. That the head be placed low when face looks pale and when fainting; high when face looks red.

5. That you sprinkle cold water into his face when no pulse is perceptible at the wrist.

By so doing you *may* save the patient's life. Do more and you *may* be the cause of his death!

2.—Wounds.

While in contusions the skin remains entire, in wounds it is divided and thus the deeper tissues of the body are exposed. A wound may be superficial,—in other words, the skin and superficial veins may be the only structures that are injured, in which case it may not be immediately dangerous to life. Or the wound may be deep and the more important deeper structures, such as arteries and nerves, muscles and tendons, may have suffered, in which case life may be endangered from loss of blood. Both deep and superficial wounds, however, equally expose the organism to the danger from infection by micro-organisms, and hence the greatest amount of surgical cleanliness is always called for in the dressing of all wounds, whether they be superficial or deep, great or small.

Just as in the case of a contusion, the gravity of a wound differs in accordance with its location and the consequent amount of injury done to the deeper parts, namely, arteries, nerves, lungs, heart, brain, stomach, intestine, liver, etc. But let us, for the present at least, disregard all such cases in which wounds are complicated by injuries to the vital organs that are contained in the different cavities of the body, and let us, furthermore, suppose for a moment that you are perfectly familiar with the means and methods of arresting hemorrhage, a subject of which you will hear in the last part of this lesson; the question arises: What is the best that *you* can do for this wound until the surgeon comes and assumes charge of it. The answer to this question that I should give would be that if, after hemorrhage is arrested, you have put on such a dressing as will prevent the invasion of the wound by micro-organisms, it is the very best that could be expected from you, and that the service which you have rendered your patient by so doing is of the greatest possible importance to him. The next question then is: What does an antiseptic dressing consist in? Antisepsis means nothing more nor less than

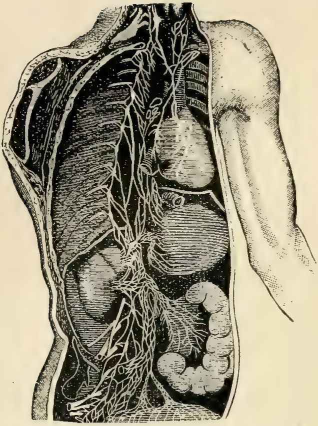


FIG. 41.—Shows the sympathetic system of nerves and their ganglia.

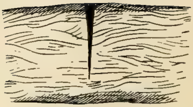


FIG. 42.—Healing by *first intention.*

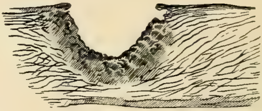


FIG. 43.—Healing by *second intention.*

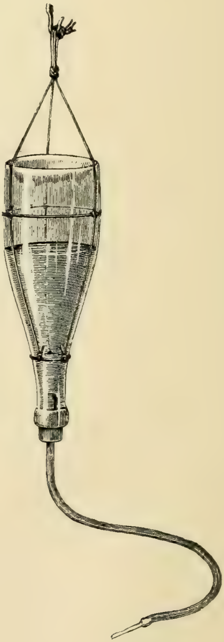


FIG. 44.—Irrigator made from a bottle.

FIG. 45.—Showing constricting bandage applied to forearm in cases of a poison having been introduced into the hand.

absolute cleanliness. In the first lesson you have learned something with regard to how this is attained so far as your own persons are concerned; the same principles also apply to all wounds, only the practice differs somewhat. To a freshly made wound you would not apply a brush and wash with soap and water, but the surface of the skin around the wound should be treated thus. All clothing in the neighborhood of the wound should be removed; your own hands should be scrupulously clean, the wound should not be touched with anything that is not absolutely clean; anything adhering to the wound, such as clothing, sand, etc., should be carefully removed; the wound itself thoroughly cleansed by irrigation with some antiseptic lotion; a compress of antiseptic cotton and gauze put over it and a clean bandage over the whole. In the practical part of this lesson we will put on such a dressing and make you perfectly familiar with the method of doing so. Of course, the injury which you are called upon to treat may happen to be in a place where antiseptic solutions are not available. Under these circumstances you must let your theoretical conceptions of cleanliness be your guide, use water in abundance and do the best you can and your duty will be done.

Let us next consider wound-healing. How do wounds heal? While every wound calls for some special treatment which must be determined upon by the attendant surgeon, nature, broadly speaking, brings about healing in two ways, namely:

1. Very quickly, through agglutination, without suppuration and with a fine linear cicatrix (fig. 42). It is always and should be the intention of the surgeon to aid nature as much as possible to bring about this rapid form of healing of wounds, which process, however, can only take place under the following favorable conditions, namely: (a) the margins of the wound must be brought into exact contact; (b) bleeding must have been so thoroughly arrested that the margins will not again be separated or pressed apart by secondary hemorrhage; (c) the parts must be kept at absolute rest by properly applied apparatus; (d) the wound must be in a state of asepsis, that is, absolutely clean (fig. 42).

2. The second form of wound-healing takes place slowly, with suppuration and under the formation of proud flesh, finally leaving a broad red scar or cicatrix. This form of healing takes place whenever the above-named favorable conditions are wanting, namely: (1) whenever a good deal of skin was torn away, so

that the wound gapes, or when its margins have been so thoroughly bruised up that they are absolutely dead; (2) when, through bleeding, the margins of the wound are pressed apart; (3) whenever the injured parts are not kept at the requisite rest, through bad transport or insufficient apparatus, which is most likely to happen in times of war; (4) wounds never heal by first intention unless they were in a state of asepsis at the time the sutures were put in (see fig. 43).

Every particle of dirt that was left in the wound sets up local inflammation, which is accompanied by that slow and tedious process known as suppuration. The matter accumulates, presses apart the margins of the wound, proud flesh grows up from the bottom of the wound and a broad cicatrix results. But besides this, the infection of wounds and their subsequent suppuration induce a far more serious condition than the production of a merely unsightly scar; they are accompanied by what is termed wound fever, threatening the very life of the patient. This, however, was the usual way in which wounds were allowed to heal, up to about 20 years ago, when surgeons began to find out the great importance that absolute cleanliness played in the healing process of wounds. In fact it is doubtful that the very significance of the word cleanliness was understood previous to that time, certainly not in its relation to the process of the healing of wounds.

The object of the surgeon is to produce healing according to the first method, if otherwise the circumstances are favorable and will permit it. This process is also called "healing by first intention."

The surgeon endeavors, if possible, to bring the margins or edges of the wound together, keeping them in contact throughout by means of properly adjusted sutures that are supplemented by a supporting bandage. Plasters for the purpose of bringing the margins of wounds together belong to the old method and find no place in modern surgery. All bleeding is arrested by the tying or ligating of all the vessels, arteries and veins with threads of cat-gut properly prepared and previously made aseptic. Cat-gut is used for this purpose because it is absorbed by the system during the period of healing, and hence these ligatures do not require removal.

The wounded part is completely surrounded by a permanent

dressing, affording it not only absolute rest, but also protection from injury and dirt; formerly the dressing was removed daily; now the first dressing remains until the wound has had time to heal, a period varying from 10 to 14 days.

But the most important factor in the quick process of wound-healing is and remains proper attention to surgical cleanliness, as has already been described.

The processes going on in the wound while it is healing are, under normal circumstances, about as follows: The edges of the wound having been carefully adjusted, an effusion of lymph from the divided lymph-vessels takes place; this lymph coagulates and forms a sort of cement which glues the surfaces together. A new formation of blood capillaries and a proliferation of connective tissue corpuscles follows immediately and, in the end, brings about the more organic union of the parts. The whole process is completed within about one week. If, however, it should happen that the two wound-surfaces were not in close contact, the remaining space would be filled with coagulated lymph and blood and would form what is generally called a "dead space." Providing the wound was aseptic, a rapid division and proliferation of connective tissue corpuscles would take place from the walls of this space, new formation of capillaries would quickly follow, accompanied by the immigration of white blood corpuscles which would quickly consume the coagulated mass, and a broad cicatrix be the result. In either case there is no fever nor any other disturbance of the bodily functions, the patient feeling perfectly well. A freshly formed cicatrix is always red, from the large number of newly formed capillaries which it contains; as these disappear in due time the cicatrix assumes the paler color of the surrounding skin and becomes less noticeable. The question is often asked as to whether this or that wound will leave a scar. Whenever the skin is divided in its entirety, a scar will surely be the result; but when the epidermis alone is divided without including its underlying connective tissue cutis, then no scar need be feared.

The second form of wound-healing is, as has been remarked, accompanied with suppuration. Up to about 20 years ago suppuration was believed to be a necessary accompaniment of the healing process. We now know for certain that the process of suppuration in a wound is an abnormal one, produced by the invasion of the wound by a well-defined species of micro-organism;

we can, furthermore, most positively assert that these same micro-organisms are the direct cause of the so-called wound-fever which invariably accompanies this form of healing. In this form of healing the same division and proliferation of connective tissue corpuscles and migration of white blood corpuscles take place as in the other form, but their fabric is interfered with by these micro-organisms, the building material destroyed and discharged and hence lost to the economy. Under proper care healing finally takes place by the formation of granulations from the bottom up and resulting in a broad cicatrix.

Let us now assume we have before us a fresh wound which is covered by a cake of coagulated blood, what are you to do with it? Whenever the dressing to be put on is intended to be merely a temporary protection of the wound from infection until the surgeon arrives, then you may confine your work to cleaning the surface of the wound and the surrounding parts with some antiseptic lotion without interfering with the blood-clot, and cover it with antiseptic gauze and a bandage.

If, on the other hand, more than 12 to 24 hours be most likely to elapse before surgical aid can be secured, then the coagulated blood-clot had better be removed by an irrigator; some iodoform must be dusted over the surface, 8 or 10 layers of gauze, best iodoform gauze, placed over it and folded large enough to slightly overlap the wound; a sheet of India rubber cloth is now placed over the gauze and some absorbent cotton over the latter; the whole is covered by a bandage and the part of the body in which the wound has occurred kept at rest. The India rubber cloth is to prevent the air getting into the wound which might be infected, and also to prevent too rapid drying of the exuded lymph and give rise to an inconvenient scab.

In hospitals so-called irrigators are in constant use; these are simply vessels of either glass or metal and provided with rubber tubes through which the outflow can be regulated. A fine stream of most any antiseptic lotion may in this way be made to flow over any wound for the purpose of cleaning it and disinfecting it. Such an irrigator may be extemporized in a simple manner from any bottle. A bottle is provided with a doubly perforated cork; into one of the holes in the cork a short piece of glass tubing is introduced and into the other a long piece reaching to the bottom of the bottle. The bottle is now filled with the lotion and the cork

with its glass tubes fitted to the bottle. On inverting the bottle a fine stream will flow through the short tube and may be directed anywhere.

The second or air tube may be omitted, if we cut off the bottom of the bottle (fig. 44). This can be accomplished with a stout cord passed around the bottle once or twice at a point at which it is intended to cut, the ends of the cord to be fastened. The bottle is now moved to and fro very quickly until by the friction that point has become very hot, then cold water is poured over it and the bottom will crack off.

Sponges are never used now-a-days in the treatment of wounds. The difficulty in the way of cleaning them thoroughly has determined surgeons to discard them altogether. Absorbent cotton soaked in some antiseptic solution and then pressed out is an excellent substitute for the sponge and is now generally used.

There are sometimes combinations of circumstances that require you to watch your wounds with special care and vigilance, and to which it may be well to call your attention before closing this chapter. Whenever it happens that a wounded person has become unconscious either owing to loss of blood or to shock, all hemorrhage would naturally cease, though large blood-vessels may have been divided and lie gaping at the bottom of the wound. In such cases the hemorrhage would recommence on the return of consciousness, and unless it would find you prepared to meet this emergency your patient would most surely succumb.

The most important disinfectants used in the dressing of wounds and the cleaning of the hands are the following:

Carbolic acid	2–3 per cent.
Boracic acid	2–3 "
Thymol	1 "
Benzoic acid	½–1 "
Salicylic acid	1 "
Chloride of zinc	1–3 "
Corros. sublimate	½–1 per thousand.

Poisoned Wounds. — Sailors, especially men-of-war's men, traveling all over the world and spending a good share of their time in tropical countries in which snakes and other animals are plenty and the bites of which are more or less poisonous, should be somewhat familiar with the methods of treating poisoned wounds.

Whatever is to be done in such cases must be done quickly. Any poison introduced into the system through a wound is taken up either by the veins or the lymph vessels, which, as you will remember, carry their contents, and consequently any foreign substance gotten into them, towards the heart.

Accordingly, your first thought must be of the prevention of this, and you can keep the poison from getting into the circulation by applying a constricting bandage above the wound, that is, between the wound and the heart (fig. 45).

Wounds from poisonous snakes, poisoned arrows, insects or dogs must all be treated alike. After the bandage is secured, rub the limb in the direction from the center towards the periphery, beginning at or near the bandage, thus squeezing out any poison which may have entered the lymphatics; then wash out the wound, burn or cauterize it as much as may seem necessary.

Internally, the administration of whisky with a small amount of ammonia added to it has, according to the most experienced travelers, proved of great service. A large quantity of drinking-water should also be kept ready, for thirst comes on after a time and is very urgent. This thirst had better be satisfied.

Hemorrhage.—The prompt and effectual arrest of hemorrhage must be considered the first and foremost duty of the first-aid-man.

Every wound bleeds because in every wound certain blood-vessels have been severed and from their divided ends blood must flow. The character of the hemorrhage varies, very naturally, with the depth and extent of the wound and the kind of vessels wnich were divided. Thus, for instance, in cases in which blood merely oozes out of the wound, not very copiously at that, we probably will find, on closer examination, that the divided vessels are of the smallest caliber, called capillaries. Whenever blood flows in a constant stream and is of a dark color, it most likely comes from a divided vein (see fig. 46). When, however, the color of the blood is of a bright red or scarlet, spirting out of the wound in an intermittent stream, then you may be sure that one of the arteries has been wounded (see fig. 47).

Hemorrhage from an artery is by far the most dangerous form, the danger increasing in direct proportion to the diameter of the bleeding vessel; the hemorrhage will also be greater when the artery has only been partially divided than it would be had it

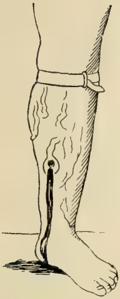


Fig. 46.—Venous hemorrhage.

Fig. 47.—Arterial hemorrhage.

Fig. 48.—Method of making digital central compression over the femoral artery.

Fig. 49 —Digital compression of the carotid.

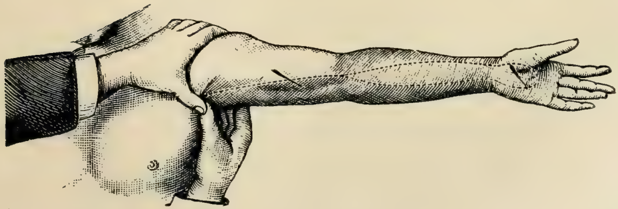


Fig. 50.—Digital compression of the brachial against the head of the humerus.

been completely cut across. Arteries that are completely cut across retract into the tissues and their lumina become much smaller than normally; the internal coat of the artery, besides, curls upon itself and sometimes entirely occludes the vessel. Arteries that are merely wounded cannot save themselves in this way.

The first thing to be done, in cases of arterial hemorrhage, is to compress the bleeding vessel with the fingers either locally, in the wound itself, or at some point of its course outside of the wound. This is called *digital* or *manual* compression. Compression of the artery in the wound, or *local* compression, does not require as much force as compression outside the wound or central compression; for the former method only one hand suffices, its thumb or two of its fingers resting on the vessel; in central compression both hands are generally needed, on account of the great resistance offered by the tissues surrounding the vessel. In order to find the vessel in its course outside the wound you must be sure of your anatomical guides, for pulsation is either very feeble or altogether absent in a bleeding vessel, especially so after considerable loss of blood has taken place.

After having found the vessel, surround the limb with both hands (see fig. 48) and place both thumbs, one on top of the other, over the vessel, using, however, only one thumb at a time for compression; as soon as the one thumb gets tired, compress with the other without changing their former position. It is in this way only that digital compression can be kept up for any length of time, otherwise the strength would fail in both thumbs at the same time and any further compression of the artery become an impossibility. Instead of the thumbs, the finger-tips may also be used advantageously, but then, of course, the surrounding of the limb with the hands is not possible at the same time.

In trying to find and compress an artery in its course it will be well to remember that all large vessels lie on the flexor side of the extremities and that it is always preferable to make compression over the main trunk of the vessel. In hemorrhage about the head and face, it is the large neck-artery, the carotid, which needs to be compressed; in hemorrhage from the arm it is the axillary artery, and in the lower limb it is the large thigh-artery or femoral.

The large arteries in the neck, or carotids, lie on either side, beneath and behind the two long muscular cords that reach from

the top of the sternum to a point behind the ear. For the purpose of compressing these, and in order to avoid compressing the windpipe and thus interfering with respiration, both hands must be used, and the finger-tips pushed in underneath these muscles from both their margins and the artery compressed against the spine, as shown in figure 49.

The artery of the upper arm, the brachial, as it is called, runs along the inner margin of the large flexor muscle, the biceps, and may there be compressed against the large arm-bone, or it may be followed up into the axilla and compressed against the head of that bone (see fig. 50); in cases where the great arm artery is cut in the axilla, pressure must be made over the collar-bone and the artery compressed against the first rib, at the same time pulling the shoulder forcibly backwards (see fig. 51).

The main trunk of the artery of the lower limb runs from about the middle of the groin towards the inner side of the knee, and may be compressed in the upper two-thirds of its course against the thigh-bone, as shown in fig. 48.

Besides *digital* or *manual* compression, we have also what is called *instrumental* compression, in which tampons and bandages are used to take the place of fingers and hands. Just as in digital compression, we may here also, according to circumstances, employ either local or central instrumental compression. In local instrumental compression the wound must be packed with antiseptic tampons and surrounded by a bandage (fig. 52); in the extremities, besides making compression over the wound, the parts below must be surrounded with a snugly fitting bandage, especially if the compression at the wound is to be kept up for some time.

In central instrumental compression tourniquets were formerly used, but actual experience in the field as well as in hospitals has demonstrated their uselessness, so that they are now altogether obsolete. In this form of compression the simplest piece of apparatus that is used consists of a plain piece of cloth, handkerchief or neckerchief, which is wound around the limb; a short stick is then pushed underneath it and turned until the bleeding stops. In order to avoid including folds of the skin in the twist a piece of pasteboard or other substance is placed between it and the skin, as shown in fig. 53; another method of compressing the brachial artery may be seen in figures 54 and 55. But the safest and surest

FIG. 51.—Digital compression of the subclavian against the first rib in cases of hemorrhage from the axillary artery.

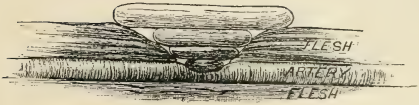


FIG. 52.—Local instrumental compression by tampon made of iodoform gauze.

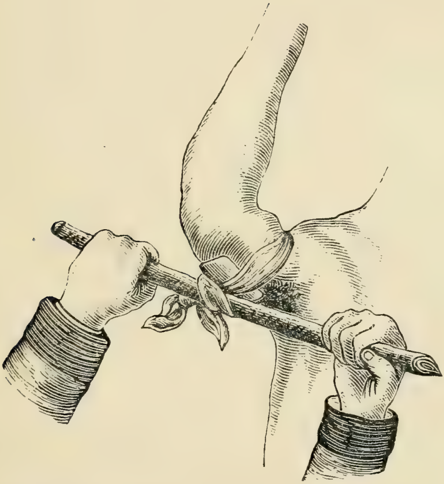


FIG. 53.—Central instrumental compression of the brachial by means of a triangular bandage.

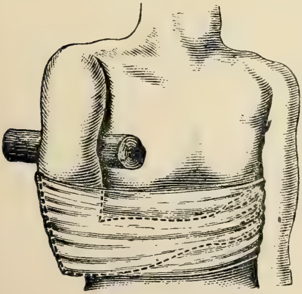


FIG. 54.—Other methods of compression of the brachial artery.

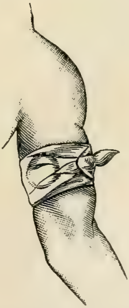


FIG. 55.—Other methods of compression of the brachial artery.

FIG. 56.—Central instrumental compression of the femoral.

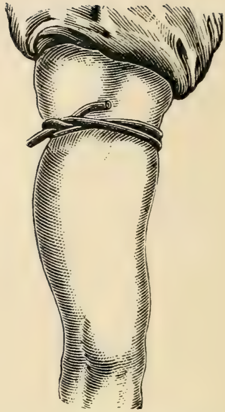


FIG. 57.—Same as 56, by means of a piece of elastic tubing.

FIG. 58.—Shows method of applying elastic bandage for the purpose of compressing the femoral artery.

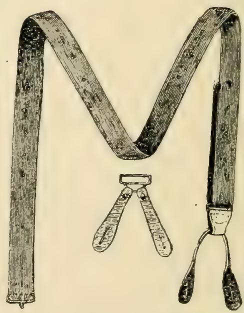


FIG. 59.—The elastic suspender of Esmarch.

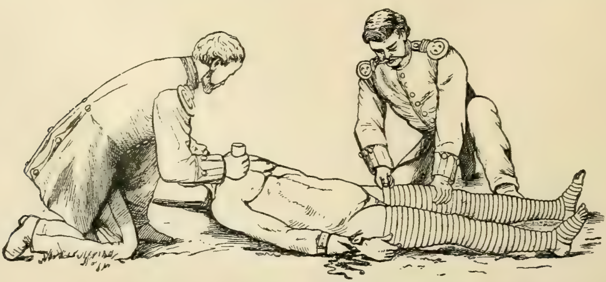


FIG. 60.—Auto-transfusion.

method of instrumental compression is that of surrounding the limb with an elastic cord, and it matters not whether this is an elastic bandage, a piece of rubber tubing, or even an elastic suspender (see figures 56, 57, 58 and 59). In all cases of hemorrhage of whatever kind, the vertical suspension or passive elevation of the limb will always be found to prove a great aid in our efforts of accomplishing its arrest.

In this circular method of compression it is quite necessary that it be complete. If this is not the case,—in other words, if blood continues to flow through the main trunk of the vessel into the part of the limb beyond the point where circular compression is being made, it will be noticed that the hemorrhage from the wound suddenly increases on account of the veins above the wound being compressed and the return of blood prevented. The complete arrest of hemorrhage alone proves that your compression is an effectual one, and this must be your aim.

In cases of hemorrhage from the veins, local pressure at the wound by means of an iodoform gauze tampon is mostly always sufficient; in cases requiring circular compression it must, of course, be remembered that the compressing bandage is to be applied peripherally, not centrally.

Capillary hemorrhage is most always arrested by elevation of the limb and constant pressure with an iodoform tampon kept up for five minutes. Iodoform gauze is the best material for these tampons because it possesses both hemostatic as well as antiseptic properties.

So far we have only considered the subject of arresting hemorrhage from the extremities and the neck; we must next in order consider cases of hemorrhage from the different cavities of the body and their treatment.

Hemorrhage from the external ear is rarely, if ever, profuse, arising, as it does in most cases, from a ruptured ear-drum; it is best treated on the principles of a wound, namely, the passage leading to the drum must be thoroughly cleaned out and disinfected and stuffed with antiseptic cotton or gauze. Absolute bodily rest, elevation of the head, with ice over the injured side, will do the remainder.

Bleeding from the nose, when due to an injury, must be treated by absolute rest and the application of ice-bladders to the head and neck. Caution your patient against blowing through

his nose or snuffing up anything. If the hemorrhage does not yield to these means, the nares must be plucked up by the surgeon.

Hemorrhage from the mouth is most easily arrested with either cold water or pressure with the finger made on the bleeding point. In case of bleeding from the sockets of the teeth, which is sometimes very persistent and threatens to become dangerous, the sockets must be tamponed very tightly with bits of iodoform gauze.

Hemorrhage from the lungs, due to external violence, commences with a certain amount of blood being coughed up and expectorated. In such cases all direct methods of arresting the hemorrhage are, of course, out of the question. All the first-aid-man can be expected to do is that he place his man at rest and thus keep him from further harm; the head and body should be elevated, ice-bladders placed over his chest, head and neck, and iced drinks administered internally; keep a little ice in his mouth and also administer some salt dissolved in very cold water. Drugs for the purpose of causing vascular contraction, such as morphine and ergot, must only be given by the advice of the surgeon.

Whenever blood is vomited up, the source of the hemorrhage is most probably in the stomach or stomach-tube, resulting from direct injury of these organs; the nature of the external injury, the place it was received, will, in most cases, greatly assist you in your diagnosis. Such an injury is most always accompanied by a great sense of fullness over the organ, with great sensitiveness on pressure, sweetish taste in the mouth and nausea. The vomited masses consist for the most part in partly fluid, partly coagulated dark masses of blood, never of a bright red color and uniformly mixed with the other fluids, as is the case when the blood is coughed up from the lungs. If the stomach contained particles of food, these will, of course, form part of the vomited mixture. Sometimes it is very difficult, indeed, to exactly locate the source of the hemorrhage coming from the mouth; it may come from the mouth itself, from the nose, the ear, the pharynx, the stomach-tube, the stomach, the larynx, trachea, or the lungs. In such cases the diagnosis can only be made by an experienced physician or surgeon. Fortunately for the first-aid-man, the general care and treatment in all such cases are so much alike that it is of no immediate practical importance whether the exact source of the

hemorrhage is recognized. If, however, the stomach is suspected to be the source of the blood which was vomited up, put your man at rest and administer iced lemonade or alum water internally, making at the same time warm applications to the extremities, cold applications over the stomach.

Hemorrhages into the intestinal canal are not immediately followed by bloody stools, as might be expected, but may be recognized by symptoms indicative of great loss of blood somewhere, leading even to unconsciousness in some very bad cases. The patient suddenly becomes very pale in the face, the lips lose their usual red color, the eye loses its accustomed brilliancy, the whole body and limbs become cold, fainting spells come on, the abdomen begins to swell up and shows great and increasing sensitiveness. Besides absolute bodily rest, the local application of cold and also bandaging the abdomen with elastic bandages may eventually save the patient. Later on, when all danger from death by loss of blood is over, the very characteristic bloody, black, tar-like stools are passed. It may happen that your patient has lost so large an amount of blood before the hemorrhage was successfully checked, that life cannot be sustained on the amount that is left in his vascular system. Feeling for your patient's pulse at the wrist, you may find it either very feeble or altogether absent. Remembering that the heart is a pump and that any pump ceases its work unless supplied with water, so also the heart will stop working unless supplied with blood under a certain pressure, absence of the pulse at the wrist means stoppage of the heart's action, due to a lack of blood in the systemic vessels. One fainting-fit quickly follows upon another, on account of the nerve centers not receiving the necessary amount of nourishment to sustain them in their functions, and death seems unavoidable.

In these cases attempts at revival must be made and kept up patiently and with perseverance and judgment. The first and foremost duty to be fulfilled is to get blood enough into the heart to cause it to resume its action. With this object in view, the blood which is contained in the legs and arms is sent into the blood-vessels of the trunk by their being carefully surrounded throughout with elastic bandages. In this manner these limbs are for the time being excluded from the general circulation, the blood which they contained is squeezed out, as it were, from their vessels and sent into the interior of the body, and the heart, of course,

receiving its share also, will begin to beat again. Inasmuch as this process of elimination of certain members of the body from circulation can only be kept up for a certain limited period of time, only two limbs are excluded at a time, one arm and one leg. After an hour's time these are released and the other corresponding members are taken in hand. This process may be kept up for days without in any way endangering the future usefulness of the members involved, your patient's life thereby saved.

The method usually employed is to take the right arm and suspend vertically and eliminate, say, the right leg from the general circulation by means of an elastic bandage applied to it from the toe up to the groin; after an hour's time, treat the left side in the same way, releasing the right side. In the meantime your patient may be fed on liquid food, such as milk and brandy, beef-tea with the yolk of egg, champagne and other light wines; patients unable or refusing to take nourishment must be fed through the stomach-tube.

The method of temporarily eliminating different parts of the body from the general circulation and infusing their blood into the remaining parts of it, is called *auto-transfusion* (see fig. 60).

Before closing the chapter on hemorrhage I must call your attention to a class of cases, instances of which you will, no doubt, meet with much oftener than you would be inclined to expect, and which present all the chief characteristic signs and symptoms of great loss of blood. Any ordinary fainting fit, little thought of by some and lightly talked about by others, presents, nevertheless, some of these grave symptoms, although not a single blood-vessel is ruptured; such cases simply mean an insufficient amount of blood in the left side of the heart and the systemic arteries, owing either to tight lacing or some other direct interference with the return circulation, or owing to vitiated air, in which case they are brought on reflexly, or both these combined.

Another example illustrating almost exactly the same condition of affairs occurs at times on board ship. Let us suppose a fireman working in a badly ventilated fire-room on a very hot, close day when there is not much air stirring; his body, especially his abdomen, has been exposed for several hours to the influence of great heat from the furnaces of the boilers; he suddenly begins to feel faint, is relieved from duty and struggles up on deck, where he breaks down and lies for a moment almost lifeless. You feel no

pulse at the wrist and your patient looks deathly pale; under these circumstances what are you to do?

Never attempt to raise such a man from the deck, but let him lie undisturbed by any one; keep the head low, loosen all tight clothing, especially around the waist and feet; rub his legs and arms in a direction from the periphery towards the center of the body; make gentle massage movements on his abdomen or, better, surround it entirely with a compress and bandage; as soon as he can swallow give him some brandy and water.

Now, what is the condition of things in his case? If we could look into his chest and abdomen we would find all the numerous veins of the entire intestinal canal, peritoneum and of other viscera contained in the abdominal cavity intensely injected with blood, their coats almost paralyzed; the arteries and the left side of the heart would be found empty, and consequently the heart has ceased to beat. The man is practically dead, and beautifully exemplifies the possibility of one's bleeding to death into one's own veins. No matter, then, where the blood is; as long as there is none in the left heart and the arteries, the man must die. Therefore, all indications for treatment in these cases are the prompt employment of all such means as are calculated getting the blood contained in his over-distended veins back into the heart. You lay him flat on his back to facilitate the flow of blood back to the heart, you make pressure on the abdomen and rub his legs and arms centripetally with the same object in view: you give him brandy internally in order to induce peristaltic or vermicular contractions of the intestinal canal whereby the over-distended veins are freed from the blood which they contain. All these means have the same object, and until this is attained our patient will remain dead; with the equalization of the circulation, however, quick recovery follows.

Practical exercises in dressing and arresting hemorrhage from different parts of the body.

LECTURE IV.

FRACTURES.

The force required to break a thoroughly sound bone is generally quite considerable; fractures that are caused by mere muscular contraction, on the other hand, almost always indicate a diseased or abnormal condition of the bony substance. Fractures caused by *direct* violence are almost always associated with severe contusions of the soft parts; there are, however, also instances where the bone against which the violence was directed resists and causes the fracture of a neighboring bone in an *indirect* manner, and in such cases we miss, of course, the usual contused condition of the soft parts complicating cases of *direct* fractures. You will no doubt all remember the case which occurred here not long ago of a cadet breaking his collar-bone by a fall on his side and arm; this was a typical case of fracture caused by indirect violence.

We must also remember that the bones of old people are much more prone to fracture than are those of young people, on account of the greater brittleness which exists in our bones at an advanced age. In children, on the other hand, bones often bend instead of break, that is, the fracture will be found to be incomplete, giving rise to what has been called a *green-stick fracture*, on account of the greater elasticity possessed by the bones at that age. We classify fractures according to different principles. Thus we distinguish them in accordance with the line the fracture takes through a bone, calling them *longitudinal*, *transverse* or *oblique;* we speak of *simple* fractures when the skin remains unbroken (see fig. 61); we speak of *compound* fractures when the skin is divided (see fig. 62); a fracture is called *comminuted* when the bone is broken into fragments, and it is *complicated* whenever there is an injury to a joint or internal viscus associated with it. Gunshot injuries attended by fractures of the bones are, of course, always compound and may, besides, be very much complicated with injuries to the internal organs; it happens occasionally that a

FIG. 61.—Simple fracture of tibia.

FIG. 62.—Compound fracture of tibia.

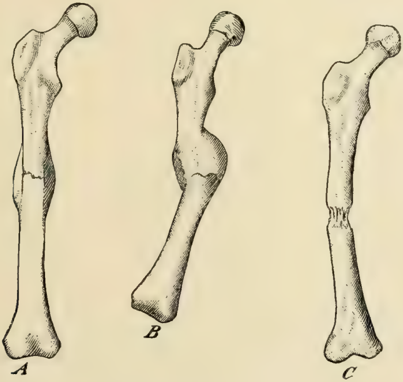


FIG. 63.—Three different forms of healing of long bone.

FIG. 64.—Shows method of setting fractures of arm and forearm.

small projectile will perforate a bone without causing it to break in two, or become embedded in its substance without even perforating it completely and lie there for years. Compound fractures are by far the most serious ones because associated with an open wound, and consequently requiring the highest class of surgical skill. The wound may be caused in two ways, namely: (1) the same force which broke the bone may also have cut the skin; (2) the broken ends of the bone may have perforated the skin and other tissues over the fracture.

Any complete fracture of a long bone is most always attended by displacement of the fragments. The kind of displacement, however, that takes place is not always the same. In a fractured knee-cap, for instance, the fragments are pulled apart and a space is left between them. In the fractures that occur in the long bones, on the other hand, the fragments override one another, owing to muscular contraction, whereby a distinct and quite perceptible shortening of the limb is produced. Although this shortening is in most instances due to muscular contraction, it may also be caused directly by the violence that produced the fracture. The least amount of displacement is generally present in fractures of the leg and forearm as long as only one of the two bones is broken.

The quick diagnosis of a fracture is in many cases easy and in others rather difficult, even for the surgeon. Subjective pains and other feelings complained of by the patient, although sometimes of great assistance and greatly helping you in making a diagnosis, must not be allowed to count for more than they are worth.

But even in cases of true fractures, mere pain does not count for much so far as diagnosis is concerned, for that is present in too many other injuries that are not fractures. Your sole reliance in a case of fracture must be placed on your own examination. You would, therefore, begin by inspecting or looking at the injured limb and by trying to discover any change in the shape of it; the tape-measure will tell you of any shortening that may exist when your measurements are compared with those of the corresponding limb of the other side. You may next try to discover any abnormal mobility about the limb and, if you discover such a place at any point of the bone, any attempt on your part to move the two fragments one over the other will be

accompanied by crepitus. Crepitus is a sure sign of fracture, but can only be made out when the fragments are still in contact with one another, that is, when there is not too much displacement. Crepitus, then, although a sure sign of a fracture, must always be looked upon as being dependent on the position of the fragments, and its absence, therefore, would not necessarily exclude the possibility of the existence of a fracture. A change in the form and abnormal mobility of the limb are most always present and therefore constitute the more important signs of fractured bones.

It is only in fractures of the skull in which this abnormal or preternatural mobility does not enter prominently into the diagnostic picture, because there the fragment is generally driven in towards the interior.

Fractures of the base of the skull are attended with the escape of a clear, colorless fluid from the ear on the injured side, and may be diagnosed with certainty in the majority of cases from this alone.

Fractures, then, may be recognized (1) by the abnormal form of the limb and the shortening of the same; (2) by the existence of abnormal mobility at the point; (3) by great pain; (4) by the peculiar grating sound produced when the two ends of the broken bone are moved against each other, as is done in setting the bone.

The normal process of repair in the case of a fractured bone is nothing more nor less than one of cicatrization in its essential elements and, as such, very much like that which takes place in wounds of the soft parts, with the difference, of course, that the process in bones takes a much longer time than in the soft parts, and, also, the resulting cicatrix is a hard, bony one instead of one of connective tissue. At first, a soft cement-like substance oozes out at the broken ends, glueing the properly adjusted fragments together; then a gradual hardening of this cement substance takes place by the deposition in it of lime salts, the mass being now called *callus*. For the complete development of this callus nature requires about four or six weeks. Should it happen that the cement substance remains soft, e. g. that no lime-salts are deposited in it, then the union between the two fragments of bone will be one by connective tissue, and, consequently, preternatural mobility at the seat of fracture will persist. This condition is called a false joint. The accompanying figure 63 shows three forms of repair in bone, namely: (a) normal healing of a well set fracture;

(b) bony union of a badly set fracture, and (c) recovery with a false joint.

The future usefulness of the limb must, of course, greatly depend upon the kind of union which results, and this again must naturally depend on how well the fracture was set in the first place. The proper healing of a fractured bone, in other words, will depend (1) on the health of the individual, (2) on the nature of the fracture, (3) on the setting of the fracture. The most important problems which the first-aid-man must keep in mind are (1) that the two surfaces of the fractured ends be brought into exact contact, and (2) that they remain in this position during the entire process of healing.

While it must be admitted that the proper setting of difficult cases of fracture is the duty of the surgeon and can only be done properly by him, there are, nevertheless, cases that come well within the precinct of the first-aid-man and in which it is his duty to try and do the best he can. The danger of delay in these cases consists in this, that the sharp-pointed ends of the fragments may work their way through the skin or, otherwise, cause so much laceration of the soft parts that they eventually die. This must be more especially considered in fractures of the bones of the foot accompanied with dislocation, and also those of the leg. A prompt adjustment and reduction of all the bones is very necessary in all these cases. In fracture of bones that are uniformly surrounded with thick masses of flesh, this danger is, of course, not so great.

The greatest care and judgment should be exercised in the transporting of these cases. Never raise a man with a broken bone from the ground without at the same time causing to be made the proper extension of the broken limb; this extension, furthermore, should be kept up while his clothes are being cut off.

In order to set a fracture properly, three things are always required, namely, extension, counter-extension, and lateral pressure. Before, however, the reduction is attempted, place your limb in such a position as to cause the relaxation of the muscles attached to either of the fragments, which is best accomplished by a position of passive semiflexion. Extension or traction is best made with the hands; counter-extension can be executed by means of a folded cloth or bandage, the loop of which encircles the limb. Both extension and counter-extension should be made with firm and

steady hands, with force superior to the muscular force to be overcome, and in the way of the reduction.

As soon as the two broken surfaces are brought up to the required point, they must be pressed together, which process requires the use of both hands to surround the limb and should be done with great care. Figs. 64 and 65 show the method of setting a fractured arm and forearm.

A properly set fracture must be supported by an apparatus; this apparatus taking, for the time being, the place of the broken bone, must, consequently, remain in position until the latter has healed and has become solid.

It must be clear that during the whole time it takes to put on this apparatus, extension and counter-extension must be kept up uninterruptedly in order to prevent a re-displacement from taking place before the apparatus is put on.

It is, furthermore, a law in surgery that every apparatus put on for the support of a fractured limb must pass beyond and secure the immobility of the two neighboring joints. An apparatus, for example, for a fractured tibia, must reach beyond the knee and the ankle, and one for the forearm must reach beyond the wrist and the elbow, and so on.

Before thinking of putting up a fractured limb, we must, of course, first make the proper splints. This is, fortunately, not very difficult, and the more familiar you are with the principles of your work and with the ends which you have in view, the more readily will you find the necessary material which will answer your purpose, no matter where the fracture may have occurred at the time. Besides with splints, broken limbs are sometimes surrounded with bandages that are impregnated with certain substances which harden on exposure to the air: plaster of Paris and tripolite (see fig. 66).

But, first aid, in most of the cases at least, will have to confine itself to the putting on of temporary splints. If the accident occurs in a town or village it is, of course, easy to secure all that is necessary in the way of splints and soft material for pads. Rulers, boards, cigar-boxes, razor-strops, broomsticks. pasteboard, felt, walking-canes, umbrellas, parasols may be obtained most anywhere. If the accident occurred in the field, branches from trees, bark, straw, hay stuffed into stockings and trousers' legs, may be made to do as temporary fracture-boxes, as shown in several of

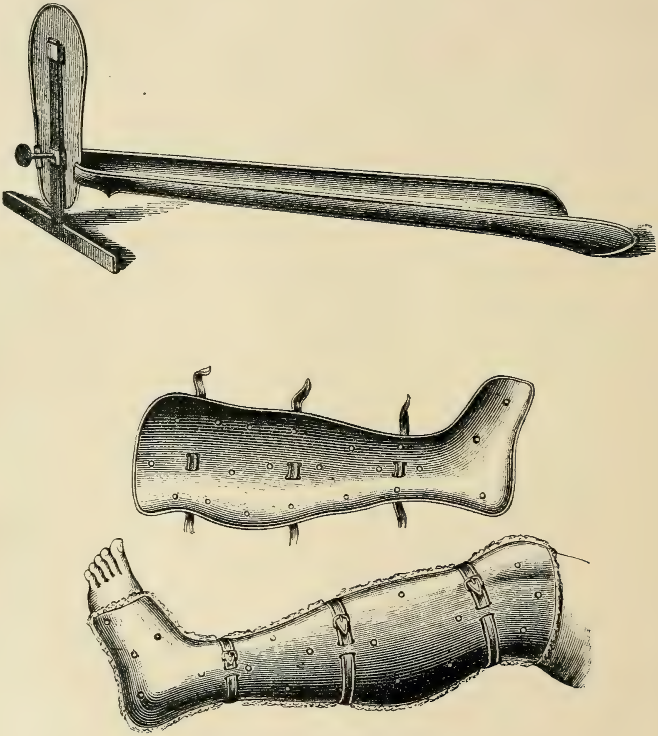


FIG. 72.—Tin splints and leg-rest.

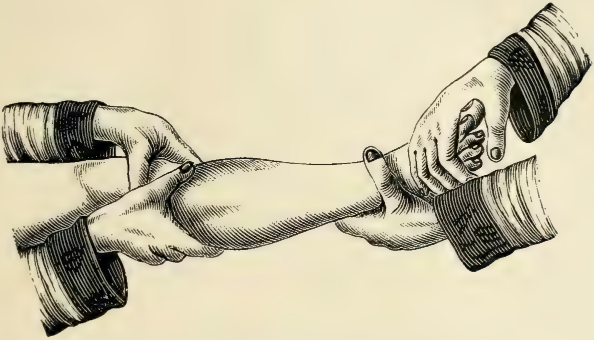


Fig. 65.—Shows method of setting fractures of forearm.

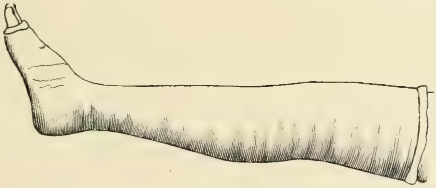


Fig. 66.—Leg and foot done up in Plaster of Paris for fracture.

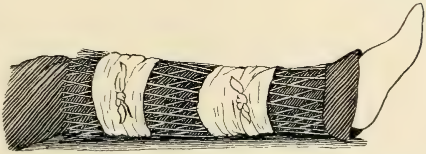
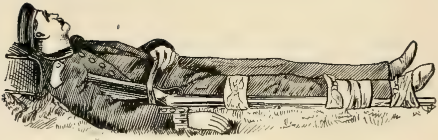


Fig. 67.—Shows various forms of extemporized splints and fracture-boxes.

Fig. 68.—Shows various forms of extemporized splints.



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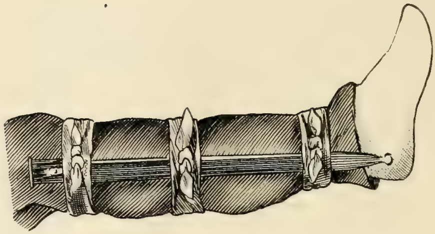

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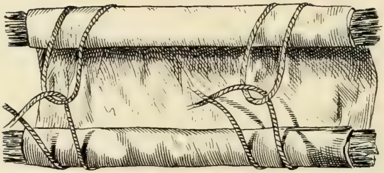

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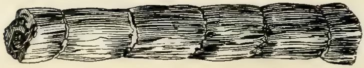


D

FIG. 71.—Shows various forms of extemporized splints and fracture-boxes.

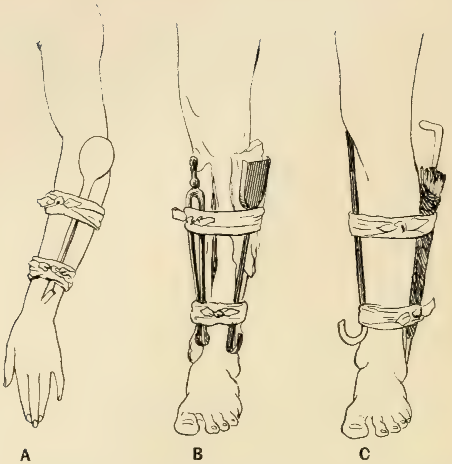


FIG. 69.—Shows various forms of extemporized splints and fracture-boxes.

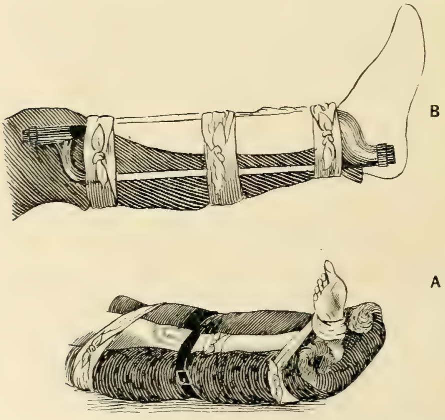


FIG. 70.—Shows various forms of extemporized splints and fracture-boxes.

the accompanying figures. (See 67, 68, 69, 70 and 71.) Most anything will do to fasten the splints on to the limb, shreds of torn clothes, strings of all kinds, suspenders, leather girdles. The accompanying figs. 67--71 show a great variety of extemporized splints as well as fracture-boxes.

Very handy things, especially for fractured legs, are the tin splints which have come into use not very long since, and which are now sold in nearly all the best drug-stores of our large cities. Fig. 72 shows some of these tin boots, made in different sizes to suit all cases and to be purchased at moderate prices.

Whatever form of splints you may use, it will always be necessary to pack them with some soft material such as cotton-wool, in order to prevent pressure on bony prominences, which not only prove very painful after a while, but which also might give rise to very unpleasant sores. Instead of bolstering the splints, cotton-wool bandages are used to surround the limbs before putting on the splints.

The splints must be secured by bandages applied over the outside, care being taken to avoid putting them over the point of fracture on account of the swelling and inflammation which usually develops at these points and the increasing tenderness of these parts.

There is no necessity for that great hurry and urgency required in cases of hemorrhage, and you will have plenty of time to set the fracture well and apply a good safe supporting apparatus before moving your patient. The point of the greatest importance to your patient will always be and remain that you should set the fracture well and, secondly, keep the fragments in position after setting them. The comfort of your patient, e. g. his freedom from pain, being, at the same time, your surest sign that all is well.

Special Fractures.—There are three kinds of fractures to which splints are never applied, namely, those of the collar-bone, ribs and skull.

Fractures of the skull are either caused by a fall or a blow, and are almost invariably complicated by unconsciousness and insensibility, on account of a certain amount of injury being done to the brain and its membranes, of which you will hear more in another lesson.

Still more serious than fractures of the vault of the skull are fractures of the *base* of the skull, which latter are caused by a

man's falling with the head upon some soft, yielding substance; the weight of the body in such a case would drive in the base of the skull and fracture it. There is always profound stupor, temporary paralysis of motion and sensation, profuse bleeding from mouth, nose, ears, blood under the conjunctiva, and escape of cerebro-spinal fluid from the ear.

In fractures of the *spine* you have simply paralysis of motion and sensation below the seat of fracture.

In all these cases the best thing you can do is to carefully move the injured person on a litter to some quiet spot with the head slightly raised. Apply ice to the head, and if the arms and legs are cold, warm flannels or sandbags to them. Administer no stimulants!

Fractures of the *ribs* require no splint, as it is impossible to obtain perfect immobility on account of the constant movement which takes place in respiration. This fracture is occasioned by blows or squeezing of the thorax, and is especially liable to be followed by secondary complications, such as inflammation of the lungs or of the pleural membranes, either of which may have been injured at the time of the accident. By placing the hand over the seat of the injury and asking the patient to cough, crepitus is easily felt. A bandage folded broad and passed around the chest is the only first aid that can be rendered in such cases. In those complicated cases in which there is perforation of the lung tissue by the sharp end of a broken rib, known at once by bleeding from the mouth, with the coughing up of blood-stained frothy sputa and the escape of air into the subcutaneous tissue, no bandage or any tight constriction must be allowed around the chest, as the broken end of the rib would thereby be further driven into the lung tissue. Braces should be loosened, stays unfastened and all impediments to free breathing removed.

Fracture of the *lower jaw-bone* may occur from blows or falls upon the chin. The mouth is found to be closed and not widely open as in cases of dislocation. The line of the teeth is irregular, as well as the external outline of the jaw.

This fracture requires two bandages folded very narrow and a splint made out of cardboard to fit the jaw so as to form a sort of cap for it. One bandage is placed below the chin and knotted at the top of the head, whilst the other, placed with its center on the chin, is carried to the back of the head, crossed and then

brought forward round on to the forehead and tied there. The ears are not to be covered over, but left in the center of the triangle formed by the bandages at the side of the head. All four ends of the bandages may be subsequently tied together.

Fracture of the *collar-bone or clavicle* is occasioned by falls on the outstretched hand. The heavy shoulder with the arm attached rolls forward and downward, the patient instinctively supporting his elbow with the opposite hand. A large wedge-shaped pad should be extemporized and put into the arm-pit on the injured side with the broad end of the pad uppermost, and this is kept in position by a bandage passed around the body to prevent movements of the arm on that side. Care should be taken not to pass a bandage over the seat of fracture or make any pressure there, because being painful and liable to displace the fragments. The hand may be supported by a sling.

Fracture of the *upper arm or humerus* occurs from direct blows or falls upon the elbow. Extension should be made and then three splints put on. The splints should reach from the shoulder to the elbow and should be placed one in front, one on the outside and the third on the back of the arm (see fig. 73). The inner splint is omitted so that no undue pressure may result to the blood-vessels lying on that side. The splints should be fastened by two triangular folded bandages and the forearm flexed and supported by a sling, which must be small and not reach up to the elbow. Be careful to put on the arm-sling with the elbow at right angles, and never allow the hand to drop lower than the elbow.

An extended trellis flower pot cover forms an excellent splint for this fracture (see fig. 67) as well as for fractures of the limbs in general; care, however, should be taken that it is well padded so as not to arrest the circulation in the limb.

In case the fracture happens to be at the lower end of the humerus, close to the elbow-joint and perhaps combined with some injury to the bones of the forearm, a rectangular splint should be applied to the inner side of the elbow-joint with the arm in a semiflexed position. Two pieces of wood can be lashed together by a bandage wound around them where the pieces of wood cross one another, and thus a rectangular splint easily constructed. Outside splints must be applied as well.

Fracture of the *forearm or radius and ulna* occurs usually from falls, but may also happen from direct blows. The arm

should be placed in a semiflexed position and two splints put on. The splint on the inner side should extend from the elbow to the tips of the fingers, and the outer one from the elbow to the wrist joint. Two bandages folded narrow keep the splints in position, and the arm is subsequently supported with a large arm-sling.

Fractures of the *fingers or phalanges* are almost always caused by direct violence. They require a long, narrow splint, which should extend from a little above the wrist to the tip of the injured finger, applied to its palmar surface. A long paper-knife answers the purpose admirably. The hand should be subsequently supported by a large or small arm-sling. Another very comfortable plan of treating this injury is to flex the fingers over a cricket-ball and bind them there.

Fractures of the *thigh bone or femur* occur from falls, and in the aged from very trifling causes. It requires two splints: the one on the outer side should be a very long one and extend from the arm-pit to the sole of the foot (see fig. 71), whilst the shorter one should be placed on the inner side of the thigh and should reach from the fork to a little below the knee-joint. Four bandages folded broadly are required. One is applied in the figure of 8 form around the sole of the foot and ankle-joint, taking in at the same time the lower end of the splint, the bandage crossing itself on the instep. A second bandage should be placed below the seat of fracture and just above the knee-joint, and a third above the seat of fracture as close to the hip-joint as possible. The fourth bandage is applied round the abdomen to keep the upper end of the splint in close proximity to the body. Finally bind both legs together, as greater support is thereby given to the injured limb.

A rifle may be used as the outside splint in this injury. The butt end is placed in the arm-pit and the stock down the leg, with the barrel towards the ground on which the man is lying.

Keep in mind that the joints above and below the fracture must be rendered immovable or as much so as that can be done.

Fracture of the *knee-cap or patella* occurs usually from muscular action and occasionally by direct blows. Two bandages, folded narrow, are required; the first is placed with its center below the knee-cap, carried to the back of the joint, crossed behind the splint, and brought above the knee-cap and tied in a knot. (A broad splint should be applied to the back of the knee-joint extending some eight inches above and below it.) The

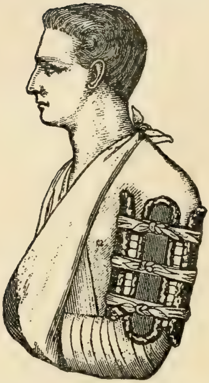


FIG. 73.—Showing position of splints in case of fracture of arm.

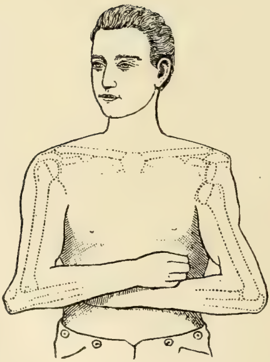


FIG. 74.—Shows dislocation of head of humerus into axilla (left side).

FIG. 75.—Dislocation of lower jaw.

second bandage is put on in a similar figure of 8 manner, but is placed first above the knee-cap, then crossed behind the splint and knotted below the knee-cap. The broken fragments, generally very widely separated, are by this means, assisted by elevation of the limbs, brought close together. The front of the joint is left uncovered, so that cold applications or an ice-bag can be applied to the swelling, which is always considerable.

Fractures of the *leg bones or tibia and fibula* are occasioned usually by direct violence, but sometimes by a sudden twist of the ankle. Two splints are required of the same length, to extend from just above the knee-joint to the sole of the foot. One is placed on the inner and the other on the outer side of the limb and kept in position by two bandages. One is passed in a figure of 8 form around the sole of the foot and ankle-joint; taking in at the same time the two splints, the bandage crosses itself on the instep. The other bandage is applied just below the knee-joint; thus all movement from above and below is prevented.

A scabbard may be used for the outside splint in this injury, or a couple of bayonets, the point of each bayonet fitting into the lock of the other (see figs. 70 and 71).

When the fibula alone is broken, the tibia forms a splint for it and people are able to walk with this fracture. Splints must be applied to this fracture in the same manner as if both bones were broken.

Fractures about the foot are always caused by direct violence. They require a special form of splint, made rectangular, into which the heel fits; the sole of the foot resting against one support and the calf of the leg against the other. The first aid consists in elevating the foot and applying cold water.

The important matter of safely transporting the injured persons will be treated of in a special chapter.

Dislocation. See figs. 74 and 75.—Whenever a bone is thrown out of the position it naturally occupies in the body, it is said to be dislocated. A dislocation is always complicated with more or less severe injury to one or more joints; its ligaments may be torn and the joint surfaces injured in various ways. As regards the reduction of a dislocation there is little to be said to the first-aid-man; the sooner you obtain medical assistance the better; for the sooner a dislocated bone is put back into place, the easier that process can be accomplished. The longer a time is allowed to elapse, the

more difficult will be the reduction of the dislocated member, it may even become entirely impossible, and consequently deformity and loss of power will remain for the rest of life. The reason why I should not advise a first-aid-man to attempt the reduction of a dislocation is the great danger with which careless and ignorant procedures of this kind have been attended. Blood-vessels and nerves have been torn across, and the entire limb even has been known to have been dragged off.

Comparisons between Fractures and Dislocations.—In both cases there is deformity and pain; but, while in fractures you will find increased and unnatural movement in any part of the limb, in dislocations you have a decrease if not entire loss of movement in connection with the implicated joint.

In a dislocation there may be shortening or lengthening of the limb, according to the position assumed by the displaced bone, but in a fracture there is nearly always a shortening, from the fragments overlapping one another. The more important distinguishing sign is the presence of a grating noise, or crepitus, in the line of the shaft of the bone in cases of fracture, while in dislocations there is an absence of crepitus and the seat of the injury is always a joint.

The distinguishing features of the two classes of injuries are best shown in the following table:

FRACTURES.	DISLOCATIONS.
Deformity and pain.	Deformity and pain.
Crepitus.	No crepitus.
Unnatural mobility.	Movement limited.
Easily replaced.	Replaced with difficulty.
Limb shortened.	Limb shortened or lengthened.
Seat of injury anywhere in the bone.	Seat of injury at a joint.

Another and final piece of advice to you is, that, no matter what the injury may be that you are dealing with at the time, always compare the injured limb with the sound one on the opposite side of the body. You will quickly perceive by comparison what you might overlook without it, namely, any irregularity in the shape or deficiency of movement, as well as any change in the respective length of the limb.

Practical Exercises.—The practical work done after this lecture consists in the making and applying of splints from all sorts of material to supposed fractures.

LECTURE V.

BURNS AND SCALDS.

There are substances which produce injuries by virtue of their chemical composition and by the chemical changes which they arouse in living tissues whenever brought in contact with them. The so-called alkalies and acids are the principal substances of this class, and caustic ammonia, soda and potash constitute the chief ones of the alkalies, while muriatic, nitric and sulphuric acids are the most dangerous representatives of the acid class.

Their effects upon living tissues, however, are so similar to those produced by burns and scalds, injuries caused by fire or steam, etc., that they may well be spoken of under one head. The eschar which these substances produce arouses local inflammation, followed by suppuration and a slow and very gradual process of repair of the injury by cicatrization through the formation of granulation tissue.

Both acids and alkalies may come in contact either with the skin or with the mucous lining of the mouth, throat and stomach. Whenever alkalies are brought in contact with mucous membranes the eschar which is formed will be of a dirty white color, while acids will produce a brown discoloration in them.

These substances are sometimes swallowed with suicidal intentions, are very dangerous in their consequences, and, when not followed by immediate death, are at least always succeeded by very burdensome strictures of the oesophagus, obliging the poor unfortunate victims to remain permanently under medical care for the remainder of their natural lives.

First aid, in these cases, consists principally in neutralizing these substances, chemically speaking; thus, in case lye was swallowed, you would have to administer vinegar or lemon-juice, and if it was an acid that was swallowed, solutions of alkalies in water or milk must be given, the best of which are magnesia and bicarbonate of soda. Injuries to the skin by these substances must, of course, be treated on the same principles.

In case any one should happen to fall into a lime-kiln, it would be a dangerous proceeding to try and wash off the lime adhering to any part of the body with water unless a very large quantity of it was on hand and complete immersion possible; if this is not the case, oil should be the thing made use of.

Burns may be produced by molten metal, overheated liquids or gases. Three degrees of burns are generally distinguished in accordance with the extent of the damage done to the parts affected. Whenever the skin is merely reddened, it is called a burn of the first degree; if the injury leads to the formation of blisters it is called one of the second degree, and if the parts are completely charred the injury is called a burn of the third degree, whether this is superficial or whether this includes the muscles and bones (see fig. 76).

The first two degrees of burns are often found together, sometimes all three degrees are found associated. Burns are dangerous injuries, being often followed by death. Fires in theaters, explosions of gas or powder, benzine or petroleum occur but rarely without some one's clothing catching afire. The victims of such accidents should be promptly warned not to run, which they most generally are inclined to do; the flames are most quickly extinguished bv the person being thrown on the ground and rolled about; covering it up with clothing, blankets, rugs or anything that may be at hand which will quickly put out the flames, such as water.

The flames having been extinguished, water in great abundance should be used, the person removed to a warm room and warm stimulating drinks administered. The clothes should be taken off with the greatest possible care; in places where they stick to the skin, the scissors must be used to cut around the adhering portion so as to leave them in place, because, the skin being the best protection, it must under all circumstances be left in place.

Blisters may be pricked with a clean needle and the fluid gently pressed out.

All these injuries soon become exceedingly painful, especially when deprived of the skin and exposed to the air, the effects of which we must endeavor to counteract by the application of oil. The complete immersion of the parts under water, or the external application of flour or raw potatoes is also very soothing.

When, however, you are treating burns of the second degree,

then you must remember that you are treating wounds, and as such all the precautions necessary in the modern treatment of wounds and of which you have heard in the third lecture of this course must be observed.

After preparing everything for an antiseptic dressing, the blisters must be opened with an absolutely clean pair of scissors, the fluid pressed out and the dead epidermis removed. The best antiseptic substance that can be used in the dressing of burns is, without doubt, the iodoform, which may be applied either in the form of the powder or in that of the liniment made as follows: Take equal parts of oil and lime-water and mix the two well together by shaking, then add to this mixture about one per cent of thymol, two per cent of creolin and ten per cent of iodoform.

After completely covering the surface of the wound with the iodoform or the liniment, put several layers of iodoform gauze over the same and a layer of rubber-cloth over the gauze; cover the latter now with a thick layer of cotton-wool and secure the dressing by a bandage. Iodoform acts like magic in these burns; but a short time after its application the excruciating pain that usually accompanies these injuries ceases altogether and the patient may then be transported without any suffering or material inconvenience.

In case the materials necessary for an antiseptic dressing are not at hand you must be content with simply pricking the blisters and squeezing out their contents, leaving on the dead skin as a temporary protection for the wound.

Effects of Extreme Cold or Freezing.

Just as in burns and scalds, we distinguish here also three different degrees, namely, the simple reddening of the surface, the formation of blisters, and the complete death of the parts.

The color of the reddened skin in cases of freezing is somewhat different from that produced by a burn. While, in a burn, the color of the skin is of a bright red, indicative of a disturbance in the arterial territories of the circulation, a sign of active inflammatory congestion, in frozen surfaces we find that the skin has a bluish-red color, which is indicative of a disturbance in the venous circulation and a sign of passive congestion and retarded return-circulation. Consequently the parts lack the local heat

and pain which we find in burns, and are, on the contrary, cold and devoid of all sensation. There is no sign of inflammation to be found anywhere about a frozen area, but instead we find oedema due to the existing passive venous congestion.

The second degree, or that of the formation of blisters, is developed slowly and not suddenly as in burns; the blisters are not so dense and so prominent as in burns, but rather flat and filled with a dirty white exudate consisting of serum and blood.

The third degree also is slowly developed; the parts dry up, turn dark brown and put on a mummy-like appearance.

Death by freezing occurs not only in the coldest regions of our earth but also in the moderate zones. When men have become very much exhausted by thirst, hunger and long marches, or are benumbed from having too freely indulged in alcoholic drinks, the prolonged influence of intense cold may go so far as to give rise to the formation of ice in the interior of our bodies, causing the fluids of them to turn solid. The tissues are thereby rendered stiff and brittle, losing at the same time their sensibility; such persons are overcome by an irresistible desire for sleep, which is quickly followed by death unless assistance is very near and prompt.

In drunkards, very much under the influence of liquor at the time, a cold wind, blowing on them for a long time, has been known to produce unconsciousness. In such persons you would find the entire surface pale and cold; the nose, mouth, hands and feet are of a bluish-red color; the pulse cannot be felt and breathing has almost or entirely ceased; the limbs are stiff and cold and devoid of all sensation.

The greatest possible caution is required in all attempts to bring such persons back to life; they must, first of all, be treated with cold, for sudden thawing would mean sudden death of the affected parts, hence avoid carrying them into a warm room immediately. If you carry the person or persons into any room at all, let it be cold by all means; their clothes should be cut off, not pulled off, and they should be rubbed with snow or very cold water; give them a cold general bath, if possible, and continue the rubbing in it. At last they may be lifted into a cold bed and covered up with some light things. The whole process should be slow and gradual and the external application of heat altogether avoided.

Internally the administration of cold brandy and, towards the end, of lukewarm tea is admissible.

If at any time during the course of treatment pursued by you it should happen that an unusual redness of the face and heat of the skin supervene, that headache comes on, with spots appearing in front of your patient's eyes, you must at once return to treatment with ice or very cold water.

If after a certain time no reaction occurs in the frozen parts, no normal warmth returns, no sensation reappears, the chance for a final return of life in them is very small.

The parts of the body most exposed to and most frequently attacked by frostbites are the nose, ears, fingers and toes.

Foreign Bodies.

Foreign bodies, so called, may become lodged in the different parts of our bodies in many various ways; they may enter through natural passages or get in through the skin in a more direct way, as through wounds. But most often they pass in through the nasal passages, through the external ear, the eyelids and the mouth.

Foreign substances having penetrated into the intestinal canal or bladder can, of course, be removed only by the surgeon.

The nasal passages consist of three rather complicated tubular cavities arranged on either side of a medium, straight partition or septum, one above the other. Things may get into them in front or from behind; these accidents happen most frequently to children who, without thinking of the consequences, will introduce peas, beans, cherry-stones, etc., while playing; more rarely it happens that certain contents from the stomach get in from behind during the act of vomiting. Whenever the object has been pushed in from in front and not very far beyond the external openings, it may be seen by a tilting up of the point of the nose under a good direct light; if it is deeper, a nasal speculum may be required to bring it into view. If it is far enough forward so it can be seen, simple bilateral compression of the nose is sometimes sufficient to expel the intruder, or a sneezing attack brought on by tickling will do it; if, however, the object is deeper, a more effectual remedy will be a rubber tube about a foot or two long; this tube is introduced into the free nasal passage and there secured as nearly as possible air-tight by outside pressure with the fingers. A sudden powerful blow from the other end of the tube

in your mouth will generally bring forth the offender. When not too far in, fruit seeds and other smaller things have also been successfully removed by hair-pins slightly bent to suit the case. In all these cases the head must be held steady by an assistant.

In the ear passages all sorts of small objects are sometimes found, but most frequently insects. The passage is about one inch in length, partly bony, partly cartilaginous. Both portions being joined together at an obtuse angle, this must be overcome, the passage straightened out so as to render inspection easier; this is easily done by pulling the ear outwards and backwards.

Here you must avoid all manipulating with hair-pins, tooth-picks and other sharp instruments which might prove very dangerous. The best method for you to adopt is that you make an attempt to dislodge the foreign body by means of a good stream of water. For this purpose, pull the ear outwards, introduce the nozzle of your syringe on the floor of the passage so as to direct the water underneath the foreign body and cause it to accumulate behind it, then make a forcible injection and the object will fly out. If success should not crown your first efforts, you must not be discouraged but repeat the maneuver.

Hardened ear-wax must first be softened up by oil before it can be washed out by irrigation.

Insects in the ear are best dealt with after the following manner: Lay your patient's head on the table, the sound ear, of course, touching the table; then introduce a sufficient quantity of oil into the other ear, so as to completely fill it, and the insects must rise to the surface because unable to breathe in oil.

We all have experienced the unpleasant sensations caused by the presence of small insects, particles of dust, etc., in our eyes; fortunately, they rarely get any further than the conjunctival sac, and most of them may be gotten rid of by rubbing the closed eye in the direction towards the inner or nasal corner of the eye, where they are swept by the aid of the naturally increased flow of tears. If, however, this little maneuver does not succeed, then the eyelids must be turned out, first the lower, then the upper, and the object removed by means of a soft handkerchief or a moistened camel's hair pencil. In case of lime having gotten into the eye, keep all water out of it, but drop some oil into the eye.

It happens not infrequently in machine shops that very small pieces of iron get into the eye, and very often, too, they will be

found seated somewhere on the transparent cornea, giving rise to the most unpleasant sensations. When on hand immediately after the accident, a good magnet is the surest means of getting them out, but later on it will require more skill than a first-aid-man would care to engage in.

All kinds of foreign substances have been known to become lodged in the throat and stomach tube. In these cases, the first-aid-man can do two things, namely, either induce vomiting by tickling the throat with a feather or finger, or cause the object to pass on into the stomach by making your patient swallow a big bolus of something like bread or boiled potato. Even if the foreign body were already in the stomach, boiled potato would be a good thing to eat, because well intended to round off sharp edges and corners, which will materially aid its passage onward through the intestinal canal and prevent wounding it.

In case leeches were swallowed, which sometimes happens when water is drank hurriedly and perhaps in the dark, strong solutions of kitchen salt must be at once administered.

Splinters under the skin and finger-nails must be removed by means of a fine pair of pincers, and should be withdrawn in a direction opposite to that in which they entered. Very fine splinters sometimes get under the nails and then break off beneath the nail and no pair of pincers are fine enough to get hold of them; these may be easily removed with the point of a needle.

Punctured wounds caused by rusty nails must be treated like poisoned wounds and under strictly antiseptic precautions, otherwise suppuration, if not lock-jaw, might follow the accident.

In cases of stings from bees and hornets, the external application of ammonia to the parts is indicated to neutralize the irritant fluid substances introduced by the insect; if inflammation should follow, cooling lotions must be applied, of which the ordinary lead and opium wash is the best.

You may some day be called upon to remove a ring from a finger that is very much swollen up. To avoid complications of this sort, it would be, of course, very much better if every one would remember in case of injury to his finger, that all rings on that particular finger should be removed immediately, before any swelling has set in. Swelling having set in, however, the ring must be promptly removed, since death of the entire finger by strangulation might result if left on.

The ring might perhaps be cut, but that requires instruments of a certain kind that are not always on hand and certain men who may not be found right off. In such a dilemma you must begin by trying to reduce the size of the finger first. With this end in view, take an elastic band and firmly apply it to the swollen finger, beginning at the tip and carrying it to where the ring is. This may be repeated several times if it should not work well the first time. The finger being now considerably reduced in circumference, a little oil is put on and the ring removed with the greatest of ease.

This process, however, would be admissible only when no suppuration complicates the case, because otherwise septic matter would surely be forced into the lymph vessels and blood poisoning result.

Drowning.

When a man falls into the water knowing he cannot swim, he generally gets so bewildered that all the efforts which he makes, frantic as they are, to save himself are directed to no purpose whatsoever and the energy which he expends is consequently wasted.

In a good swimmer, on the contrary, the very consciousness of his ability to swim keeps him perfectly cool and self-composed, and enables him to save himself and others from drowning without unduly wasting a particle of his much needed energy.

While all of you perhaps know how to swim and swim well, too, it may happen some day that the odds are very much combined against you and you become exhausted before reaching your goal and before more substantial assistance can reach you. Under such conditions and circumstances, remember these few and simple rules, which, nevertheless, may keep you from drowning: (1) Lie on your back, with the head well backwards; let the mouth and nose be the only parts of the body that are above the surface of the water. (2) Keep your lungs full of air by taking deep inspirations and short, quick expirations. (3) Leave the arms under water, as shown in fig. 77.

The fact that the human body will float when in this position depends on its being very slightly lighter than the volume of water which it displaces. When, therefore, the arms are held above the surface of the water, the head must sink, owing to the loss of displacement (see fig. 78).

FIG. 76.—Arm showing different degrees of burns.

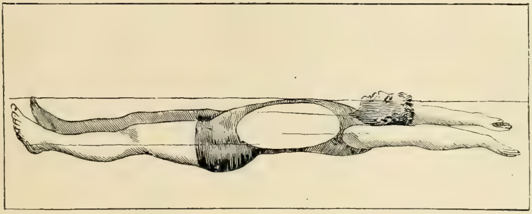


FIG. 77.—Showing how to keep horizontal position when floating in water.

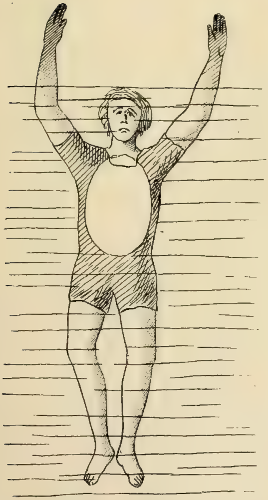


FIG. 78.—Shows how head sinks below surface of water when hands are kept above the surface.

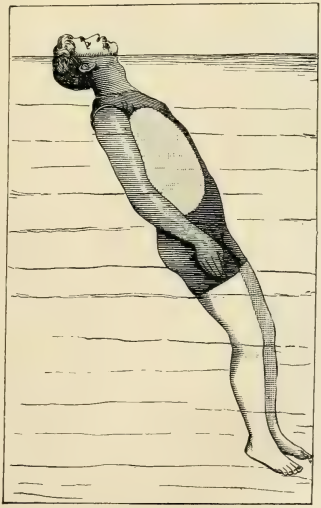


FIG. 79.—Shows position which the body assumes under water when hands are kept alongside of it.

The practice of this little maneuver should always form the first lesson in the art of swimming. The two best positions to be taken while floating in the water are represented in figures 77 and 79. When the arms are kept above the head, the position will become a horizontal one; when, on the other hand, these are kept alongside of the body, the position of the body in the water will incline towards the vertical (see fig. 79).

This is easily explained and understood by a glance at these pictures. The white oval space is made to represent the air contained in our lungs and which, therefore, answers the purpose of a swim-bladder; this space is very nearly in the center of the body whenever the arms are held above the head, and hence the horizontal position in the water; with the arms alongside of the body the greatest weight falls below this space, hence the position inclining more towards the vertical. In the vertical position the head must be bent further backwards than in the horizontal position in order that the mouth shall come to lie out of the water.

Whenever a man falls out of a boat into the water, an oar, boathook or rope may be passed him; a good little device also is your coat which you may take off, passing the man in the water one sleeve while you hold on to the other yourself.

According to Hans Mueller, a very celebrated teacher of swimming in Hamburg, Germany, and quoted by von Esmarch as having saved over 200 people from death by drowning, consequently well qualified to speak on the subject, the best method of saving life on the water is as follows: Before taking hold of the drowning man call out to him loudly that he is saved, in order to reassure him; approach the man from behind, passing your left arm between his left arm and body and seizing his right wrist and, in this manner, swim ashore on your back, striking out with your right free arm. The man is thus prevented from paralyzing your efforts by taking hold of you, which might be the cause of both drowning together. In case, however, the drowning man has seized the swimmer, the best thing the latter can do is to dive under until the former begins to lose consciousness and thus loosens his grip.

Whenever the tide is against you it will be best to float on your back with the tide and not exhaust your energies by trying to swim against it, and quietly wait for assistance to arrive.

Whenever any one breaks through thin ice, as is frequently the case during the skating season, and he is unable to extricate himself, the best help will be a long ladder or board intended to distribute the weight over a larger surface of the ice and upon which the boy may crawl out. Another very good means is said to be a wooden ball, such as is used in bowling, made fast to a rope and rolled out to him until it drops into the water; to this he can cling until further assistance arrives (fig. 80).

In approaching a man broken through weak ice, you must take the precaution either of crawling up to him on your stomach or at least arm yourselves with a long pole or boat-hook, which you must hold to your back with your elbows, as shown in fig. 81.

Death under water may be produced in two ways:

1. By suffocation, through water getting into the lungs.

2. By fainting.

Whenever death is brought about by suffocation, the face of the drowned person will present a puffed-up, swollen appearance, the skin of his face will be of a dark bluish color, particularly noticeable about the lips and eyes; there will, furthermore, also be a good deal of water found in the stomach and the lungs.

In cases of death by fainting, the face will look pale and there will be no water in the lungs, the spasmodic closure of the glottis over the wind-pipe having prevented its entrance there. It is much easier to revive one of the latter class than one of the former.

However, every drowned person ought to be looked upon as only seemingly dead, because it has happened that persons were brought back to life even after remaining under water for hours.

Attempts at resuscitation should be undertaken and conducted with confidence and perseverance and continued for several hours.

The following rules are borrowed from Prof. v. Esmarch's "Erste Huelfe," their observation is recommended to all whose duty it may become to save a drowning person, the rules themselves having been adopted by the German Samaritan Association. They are:

1. As soon as the drowning person arrives on shore send for a physician, for woolen blankets and dry clothes; take off all the wet ones.

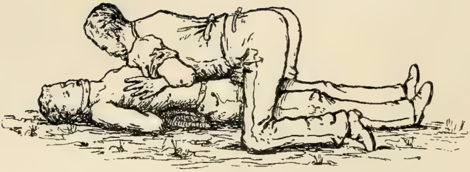
2. At once begin with your efforts at resuscitation, if possible in the open air, weather, of course, permitting.

3. Always remember your first duty to be the re-establishment of his breathing.

FIG. 80.—Trying to save a person broken through the ice by means of a wooden ball attached to a rope.

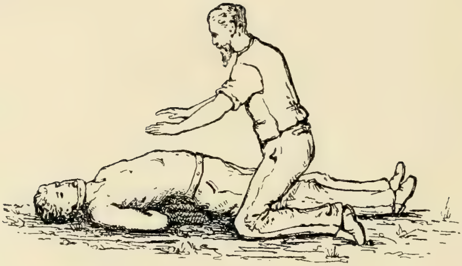
FIG. 81.—Manner of approaching a person broken through weak ice.

FIG. 82.—First step in the resuscitation of a drowned person.



A

FIG. 84.—Howard's method.



B

FIG. 84.—Showing Howard's method.

FIG. 85.—How to push the lower jaw forwards.

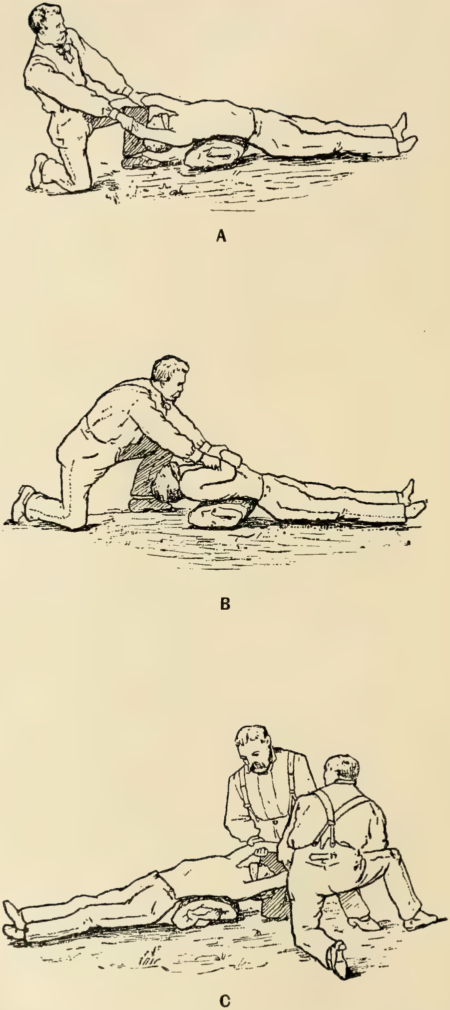


FIG. 83.—Illustrating the different steps in Sylvester's method of resuscitation.

4. Efforts at resuscitation must be kept up for hours before hope is given up.

5. Never stand the drowned man on his head; place him over your left knee with his stomach downward, pressing on his back so as to give the water a chance to run out of his lungs and stomach (see fig. 82).

6. Clean out his mouth with a small swab and also his nose so as to allow air to enter; if the tongue falls backward, pull it out, taking hold of it with a handkerchief.

7. Tickle the nose with a feather, try the effects of smelling-salts or ammonia water; rub his face and chest alternately with hot and cold water.

8. If no success follows these means, commence at once to make *artificial respiratory movements.*

9. The object of these movements is to expand and compress the chest alternately so as to force fresh air into the lungs.

10. The method recommended most is Sylvester's.

11. Put your man flat on his back, a folded blanket or coat supporting his shoulders.

12. Take your place behind him, seize both his arms near the elbows, raise them over his head, holding them in this position for a couple of seconds, as shown in fig. 83 *a*, thereby expanding the chest and forcing air into the lungs.

13. Thereupon return the arms to the side of the chest, press the elbows against the chest gently but firmly for two seconds, thereby pressing air out of the chest (fig. 83 *b*).

14. When two people are present, each may take one arm and the two work together (fig. 83 *c*).

15. These movements should be repeated at the rate of 15 times per minute and kept up until voluntary respiratory movements occur, generally announced by the red color returning to the man's face.

Another method recommended is that of Howard and illustrated in fig. 84.

16. The drowned person is placed on the back, the arms crossed behind, and a folded coat supporting the small of the back.

17. An assistant pulls out the tongue or pushes the lower jaw forward, as shown in figure 85.

18. The hands are laid flat on the lower part of the chest, and firm and steady pressure is made and kept up for two seconds.

19. Then the hands are raised, the chest expands.

20. As soon as voluntary inspirations commence, help the circulation along by hot blankets.

21. Rub the legs and arms from the periphery towards the center, as in massage.

22. As soon as both respiration and circulation have become re-established, put your man into a warm bed, surrounding him with hot bottles.

23. Finally, administer hot drinks, such as coffee, tea, etc.

These same methods of resuscitation can, of course, be applied also in cases of suffocation caused by the inhalation of poisonous gases.

Unconsciousness

Is a condition characterized by the loss of consciousness, of general sensation and voluntary movements. It may be due to a number of causes, namely: 1. Injuries to the brain. 2. Diseases of the brain (epilepsy, apoplexy). 3. Temporary anemia of that organ from loss of blood either internally or externally. 4. Difficult respiration. 5. Sunstroke. 6. Poisoning by alcohol and other narcotics.

In the treatment of the condition of unconsciousness two cardinal rules with regard to the position of your patient must be kept in mind. (1) Whenever your patient's face looks pale, the position which you must place him in is the horizontal one. (2) When, however, his face looks red, as will be the case in apoplexy, then you must raise his head and trunk and place him in a half sitting position.

In the one case you are dealing with a case of anemia of the brain, and the horizontal position is the best in this case because it facilitates the re-establishment of the circulation through the organ. In the other you have either congestion of or hemorrhage into the brain, and the horizontal position would aggravate these conditions, hence you must elevate the head and trunk.

Smelling bottles, ammonia and ether, etc., much used in fainting fits, are directly contra-indicated in cases of congestion of or hemorrhage into the brain, in other words, in cases of apoplexy.

Moreover, when finding a person struck down in the streets, never forget to take a few mental notes of the position the person was in when found by you, for this may prove of considerable importance from a medico-legal point of view.

If the man begins to vomit, turn him over on his side with the face downward, so as to prevent any of the contents of his stomach from being sucked down into the wind-pipe and the lungs, which is a frequent cause of pneumonia. The vomiting over, swab out his mouth.

An epileptic may be allowed to lie on the ground until the fit is passed; he only requires watching so as to keep him from injuring himself. Consciousness soon returns, accompanied by great fatigue; these patients never have the slightest recollection of what happened during the attack.

Sun-Stroke or Heat-Stroke.

The prolonged influence of solar heat on the more exposed portions of the surface of the skin is followed by inflammation and, may be also, the formation of blisters.

Sunstroke is a form of unconsciousness caused by hard work in an atmosphere which is overheated and oversaturated with moisture, aided by a scarcity of drinking water. Soldiers compelled to march in closed ranks for a long time often fall victims to sunstroke.

Sunstroke may be caused not only by the direct rays of the sun but also by radiated heat.

We distinguish two forms of sunstroke or heat-stroke, namely, (1) The *grave* form, which is characterized by paralysis or the suspension of all the cerebral functions, including respiration, and which is invariably followed by death. (2) The *mild* form, which frequently occurs in places where water is scarce, and is due as much to loss of water through perspiration and the consequent thickening of the blood as to the influence of the heat.

It is a good rule to take large quantities of water while at work in hot weather.

The mild form of heat-stroke commences with extreme drowsiness, stupefaction, cramps, severe headache and back-ache, difficult breathing, dark red color in the face, dry tongue, dry skin and feeble pulse.

Any person showing such symptoms had better at once be taken to a cool spot, his clothes taken off, ice applied to the head and lukewarm drinks administered; if convenient, give him a lukewarm bath to encourage perspiration; afterward put him in a wet pack.

Lightning either produces enormous burns, in some cases completely charring the parts struck, or it causes paralysis of the nervous system through the electricity which it sends into it, and the effects of which are most difficult to treat.

Apparent Death.

The condition of apparent death from real death may be distinguished as follows: 1. By electrical currents passed through the different regions of the body; the electrical excitability ceases but a very short time after death has taken place. 2. By taking the temperature in the rectum; anything below 80° F. indicates sure death. 3. By winding a string around one of the fingers; as long as the peripheral portion of the finger swells up and assumes a bluish color under this treatment, and the white place, after removing the string, turns red again, death is not real but only apparent. 4. Irritants applied to the skin, in apparent death, are not followed by blisters with a red basis, but only by elevations of the cuticle having a white ground.

The treatment of apparent death must, of course, depend on circumstances.

LECTURE VI.

THE TRANSPORTATION OF THE WOUNDED.

The best method of transporting the wounded from one part of a modern man-of-war to the other must be considered still as an open, unsettled question. Perhaps there is no one best method at all, and every new ship requires a new method and new means to this end, owing to its own peculiar construction, just as every injury may require its own peculiar handling and form of apparatus.

However this may be, the problem must have appealed to the good sense of many an able medical mind as being an important one, if the number of cots that have been designed for the transport of the injured on board ship form any criterion to judge by.

Most every man-of-war has on board at least one or two of these relics of past ingenuity, which are, however, far from answering the purposes for which they were originally intended; they all prove that the necessity for something of the kind was nevertheless felt sufficiently strong to arouse even the most phlegmatic minds into a state of productive activity.

But granting even that every one of these different cots is very good and useful, the question might still be asked, what is the use of even the best of cots without trained bearers to handle it?

The best gun in the world would be perfectly useless without the men trained to work that gun, while an inferior one might be made to do good work under the pressure of circumstances with properly trained hands and minds behind it. Just so with the handling of the wounded and the cot.

The first and most important step, therefore, that must be taken to bring about some much needed reform in this much abused and neglected department aboard ship, is to train men.

We hold that it is not the most useless and the most stupid landsman that can be found among a crew whom you would

select as the proper person to aid you when wounded or in danger of life or in sickness. Why, then, thrust him onto others?

The surgeon on board ship and his patients need, on the contrary, intelligent assistants; hands, minds and hearts that are trained in the gentle duties required from such persons holding similar positions on shore.

But it requires some knowledge and experience in matters medical, as well as in life on board ship and its possibilities, to fully see and realize how imperfect a modern fighting machine like some of the present men-of-war appear in the eyes of a naval surgeon who is mindful of the duties and responsibilities of his position, without much better arrangements being made for the care of the sick and the transportation of the crippled and wounded.

And, by arrangements, we refer not to space alone, which may be ample and yet wasted.

In some of the more modern ships the constructor seems to have entirely forgotten that it is within the range of bare possibility for accidents and sickness to occur among the crew during the natural life of his ship.

A man-of-war without any provision for the sick and wounded may indeed go out and fight his battles, so might a man without his left arm or in the last stages of consumption; neither the ship nor the man will, however, in the long run, be able to compete with his more perfectly equipped adversary and must be considered crippled to that extent.

It is not the expenditure of necessary life which we mean to save; it is the waste and unnecessary expenditure of lives which it is our aim to prevent.

The matters of fact are indeed simple and clear and scarcely need any argument, as you will readily concede.

No matter, then, where a man may have been injured, whether on land or sea, the fact remains that, after dressing his wounds, it becomes the duty of the first-aid-man to employ or improvise means for his safe transportation to a place where he may receive further treatment.

The different methods of lifting and carrying the sick or injured must vary according to the nature of the case and the number of persons available for the purpose.

(1) There are cases of injuries which do not disable any one

from walking, and such persons need, therefore, no transportation at all.

(2) When the injury has occurred to the foot or the parts below the knee, the patient may, if of light weight, be conveyed pick-a-back, putting his arm around the neck of the bearer; but this would, very naturally, be impossible if the injury were in the upper part of the leg, on account of the pain it would necessarily entail.

(3) If the patient is suffering from some injury to the upper part of the leg, is unable to walk and yet perfectly sensible, he may be greatly assisted by the bearer placing his hip against the patient's hip on the uninjured side and taking the arm of the same side, placing it around his own neck and holding it there with one hand whilst his other hand and arm encircle the patient's waist. Then, by a series of light hops, the patient can be quickly moved along and the injured limb kept well off the ground (see fig. 86).

But circumstances may be such as to require you to move unaided an insensible person.

The method that is most frequently used in such cases is the following: The insensible person is put flat on the face, with the arms extended in a line with the body, and then brought into a kneeling position. The bearer places his right shoulder against the center of the body while placing his right arm between his legs and around the right thigh; at the same time he seizes the left wrist with his left hand, taking it around his own neck and under his left arm, passes it to the right hand which grasps it by the wrist. This may be done in the reverse way and the right arm left disengaged.

(5) A slight modification is sometimes adopted as follows: The patient, lying as before, extended and flat on his face, is raised to the kneeling position by the bearer, who stands in front, putting one arm in each arm-pit. He then slips his hands and arms around the patient's waist and brings him into the erect posture with his head hanging over the bearer's shoulder. Then, grasping either wrist and passing it over the head to the opposite shoulder, he slips under the body and swings it over his shoulders, grasping the legs with the opposite hand.

(6) Another method is to place the patient in a sitting position and to pass a soldier's belt or any broad continuous strap behind the thighs and under the arms. The bearer then seats himself

dos-à-dos and, passing the strap over his own forehead, raises himself. The weight will then fall upon the shoulders and upper part of the back. The strap under the arm will prevent the patient falling out, as he will be somewhat wedge-shaped, the broader portion above and the apex formed by the buttocks below. Both arms of the bearer are then disengaged and, therefore, this method is a good one in cases that occur on board ship while in motion.

When two bearers are available things are much easier.

(1) The ordinary dandy or sedan-chair, as made by children clasping their wrists as shown in fig. 87, is, of course, well known to you. This is only adapted when the injured person is sensible, as he must support himself by placing his arms around the necks of the bearers on either side of him.

(2) Another four-handed seat is sometimes made by the bearers crossing their arms and then taking each other's hands (fig. 88); but this is a bad one and not to be countenanced, because, if the patient is at all heavy, it soon becomes most painful to the bearers at the point where their arms cross, and they will have to put the patient down to relieve themselves.

(3) Also the bearers may lock only one pair of hands under the thighs of the patient and place their other arms around his loins, while he supports himself by placing his arms around their necks. This, again, is not so good as the first described.

(4) If the patient is not in sufficiently good condition to be trusted to supporting himself, the three-handed seat should be used, as represented in fig. 89, and then the bearer whose hand is left free places it upon the shoulder of the bearer whose two hands are engaged and thus a back is formed to the seat.

(5) A seat, but not as good a one as that just described, with a back to it, may be made by the bearers locking opposite hands under the thighs and placing their other two hands on each other's shoulder, as shown in fig. 88.

(6) Two bearers may convey an insensible person by one (the stronger) of them lifting the upper half of the body by placing his arms under the arm-pits and locking his hands in front of the chest, while the other bearer goes between the patient's legs and, turning his back to the first bearer, lifts one leg of the patient under either arm, as shown in fig. 90; a third person supports the lower limb, should that be the part injured.

(7) If circumstances should make it desirable that the patient

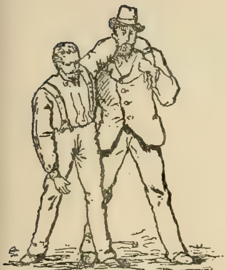


FIG. 86.—How to aid an injured person single-handed.

FIG. 87.—The ordinary dandy or sedan-chair.

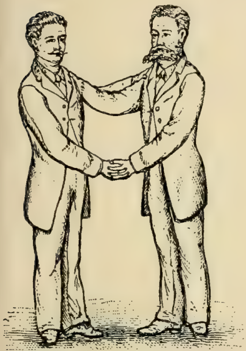


FIG. 88.—Another four-handed chair not so good as the sedan chair.

FIG. 90.—How two bearers may carry an insensible person.

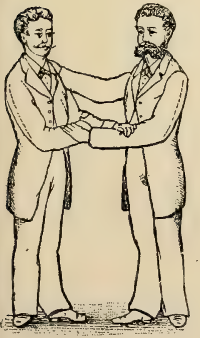


FIG. 89.—Still another chair.

FIG. 91.—Manner after which an injured person is put on a stretcher.

be carried in a more extended position, the two bearers kneel down on their left knee only, and, passing their hands underneath the patient, lock them together. One pair of locked hands is placed below the shoulder-blades and the other pair below the buttocks. The bearers then rise gradually to their feet and move the patient by sideway steps, while his head is supported by a third person and the legs by a fourth. If only one other person is available, then priority should be given to the head if the patient is insensible, or to the leg if that is the part of the body which is injured. This is also the manner after which an injured person is put on a stretcher (fig. 91).

Then, as to the manner the bearers should lock their hands: this is usually done wrongly. The bearer on one side should notice which way the other is going to pass his hands under the patient, so that the bearer at the opposite side may pass his hands with the palms uppermost, while the other, passing his with the palms downwards, must keep close to the body of the patient, so that the bearer at the opposite side may pass his hands beneath the other one's. Their hands will then be clasped as shown in fig. 92, palm to palm, and held by the thumbs on one side of the wrist and the fingers on the other. This is the only right and proper way of joining the hands.

Whenever patients are to be carried some little distance, a stretcher should always be made use of.

The lifting of patients on to a stretcher and carrying them thereon by word of command is known by the name of *stretcher drill.* Every military organization the world over has its stretcher drill. Captain John Furley, the director of the St. John's Ambulance Association of London, has drawn up a system of stretcher exercises that are purchasable at St. John's Gate, Clerkenwell.

In connection with the stretcher drill, I must quote the words of Dr. Charles Smart, Surgeon and Major, U. S. A., and author of the Handbook for the Hospital Corps of the U. S. Army and State Military Forces, who says: "Drills by word of command are needful to perfect men in all movements that require concerted and co-operative action. It is a mistaken notion to suppose that because a drill is authorized and provided for, the various details of that drill must be rigidly observed on every occasion. The idea of seizing a man whose thigh-bone or spine is broken, or who has received some injury that must remain undiscovered until a care-

ful examination is subsequently made, and lifting him to or from a stretcher by word of command, is simply absurd. The drill is merely a means to an end. A well-manned battery keeps up a rapid fire on the enemy because every man at every gun knows the duty devolving upon him and does it without command at the precise moment when it should be done; but this perfection of co-operative work can be attained only by repeated and careful drills in the consecutive movements, each executed at the word of command. An analogous drill with the stretcher and a representative of the disabled human body familiarizes men with the management of these objects and prepares them to act intelligently, one with the other and irrespective of commands, when the necessities of the occasion require such action."

These words, in our opinion, express the *raison d'être* of the stretcher drill beautifully and forcibly.

The Drill Manual issued from the office of the Surgeon-General of the Army provides for the falling in of the men for inspection, drill, or active service, and prescribes the duties of each member of the squad in connection with litters, ambulances and other means or modes of transportation.

The detachment for inspection or drill is formed in single rank, privates of the hospital corps on the right, company bearers, without arms, in the center, and musicians on the left. The senior hospital steward is on the right of the line; the other hospital stewards and acting hospital stewards are posted as file-closers, two yards in rear of the line and in order of seniority from right to left. The formation, opening and closing of the ranks, maneuvering, inspection and muster of the detachment are effected by the commands and in the manner prescribed for infantry troops, modified in certain special details as follows:

1. After fours are counted in forming the detachment, if the knapsack or medicine-case men are not already in that place, they are assigned as No. 4 of each set. The sets of four or squads are numbered from right to left, and these numbers are not changed during the exercises. The left squad, if incomplete, may remain in line on the left and its men be afterwards utilized as dummy-wounded, or ordered to practice in transferring patients to litters or to beds or in improvised means for transportation; or they may be assigned as supernumeraries and posted on the line of file-closers behind the squads to which they are attached. Super-

numeraries are attached to squads when the duty to be performed promises to be so fatiguing as to require more than the usual reliefs.

(2) When one or more squads or the whole detachment is to be mounted, the detachment having been formed dismounted, the senior hospital steward gives the necessary directions, under the instructions he has received, for the squad or squads, or the whole detachment, to be marched to the picket line or stables for their horses and horse equipments. The mounted squads are formed in line in single rank, the lowest number squad on the right. A mounted hospital steward, specially assigned to this duty, or, in his absence, No. 1 of the right squad, superintends the formation of the mounted squads at the place designated. If the whole detachment is mounted, the senior hospital steward superintends the formation. The position of the stewards and acting stewards with detachments mounted are the same as with detachments unmounted, except that the file-closers are one yard in rear of the rank, the distance being measured from the croups of the horses in the line to the heads of the horses of the file-closers. If only part of the detachment is to be mounted, the instructor receives the report of the senior hospital steward at the formation dismounted; if the whole detachment is to be mounted he will receive the report of the steward mounted.

(3) At the command, *draw*—SWORDS, of inspection those armed with knives draw them and hold them in the position of *carry* SWORDS. Inspection of the knife is similar to that of the sword or saber. First motion: Raise the right hand as high as the neck and six inches in front of it, edge of the blade to the left. Second motion: Turn the wrist outward to show the other side of the blade, the edge to the right; make a slight pause and then turn the wrist back. Third motion: Drop the right hand to the side and hold the knife as prescribed after drawing from the sheath. At the command, *return* SWORDS, the knives are sheathed.

(4) Knapsacks, medicine cases and dressing boxes are unslung, opened, repacked and slung by the commands, and as nearly as practicable in the manner prescribed for the inspection of knapsacks or blanket bags of an infantry command. The company bearers take their dressing packets in the right hand and, as the inspector passes, they advance the hands so as to display the packets.

Bearer Drill.—In bearer drill the inspector designates by their numbers the squads which he wishes to operate with the hand-litters, ambulances, etc., and assigns the hospital stewards and acting hospital stewards to the superintendence of drills that are not supervised by officers. No. 1 of each set is the ranking member and gives the commands needful for the proper maneuvering of the squads.

No. 1 of a squad designated to practice with a hand-litter procures the litter and prepares it for use, placing it lengthwise on the ground, its near end opposite and two yards in front of the center of the squad; he then resumes his place on the right of the squad and commands:

1. *To your posts;* 2. MARCH. At the second command Nos. 2 and 3 take position between the handles—No. 2 in front, passing by the right, No. 3 in rear; No. 4 takes position on the left of the litter opposite its center and one yard from it; and when No. 1 has seen that the other numbers are in their proper places, he takes his own on the right of the litter opposite its center and one yard from it, all facing to the front.

Or, the folded litter being in position in front of the squad, at the command, *To your posts*, MARCH, the members take post, No. 2 on the right of the front handles, No. 3 on the left of the rear handles, and Nos. 1 and 4, respectively, on the right and left of the litter at its mid-length, all facing to the front. Then, at the command, *Open* LITTER, 1st, all face inward to the litter; 2d, Nos. 1 and 4 bend on the knee, grasp litter with hands under poles and rise erect, holding litter horizontal; 3d, Nos. 2 and 3 unbuckle and fix straps, adjust legs and straighten transverse irons, etc. Then, at the command, *Lower* LITTER, Nos. 1 and 4 lower litter to the ground, and all resume position as mentioned above, after the command *To your posts*, MARCH.

No. 1 now commands: 1. *Prepare to lift litter;* 2. LIFT LITTER. The first command is executed by Nos. 2 and 3, adjusting the braces about their shoulders; the second by the same members, raising the litter in position to be carried, Nos. 1 and 4 standing fast. If, owing to a difference in height of the carriers, the litter is not horizontal, No. 1 directs a change in the length of the braces to correct the inequality.

He then commands: 1. *Forward;* 2. MARCH, when, at the second command, the carriers break step, that is step off with

different feet, No. 2 with the right, No. 3 with the left foot, marching with the litter as nearly as possible horizontal and taking short sliding steps to avoid jolting and to secure a smooth, uniform movement of the litter; Nos. 1 and 4 march on their respective sides of the litter.

The litter is carried to the point previously designated by the proper officer by means of the command: 1. *Litter right* (*or left*); or *Litter half-right* (*or left*); or *Incline to the right* (*or left*); MARCH.

To halt the litter and rest the squad, No. 1 commands: 1. *Litter;* 2. HALT; 3. *Lower litter;* 4. REST. At the third command, the litter is slowly and steadily lowered to the ground and the carriers release themselves from the braces; and at the fourth command, the men stand at ease in the vicinity of their posts.

To resume the attention the commands are: 1. *Squad;* 2. ATTENTION.

The transfer of a patient to a litter requires practice and the united action of two, three or all the bearers of a squad, according to the gravity of a wound or the helplessness of the patient. Every movement should be made without haste and as gently as possible, and the wounded part should be carefully protected from all injurious contact.

Having reached the sick or wounded man, No. 1 halts and lowers the litter so as to place it in front of the head or feet of the patient in the direction in which he is lying. As soon as the bearers are released from the braces, Nos. 2 and 3, passing by their right and left respectively, take position facing each other on opposite sides of the patient, near his hip-bones, and, if a limb be injured, No. 4 places himself by its side. Everything in readiness, No. 1 commands: 1. *Prepare to lift patient;* when Nos. 2 and 3 stoop down and get each one hand under the back of the patient near the shoulder-blades, and lock them by grasping firmly each other by the wrists; the other hands are passed under the upper part of the thighs and clasped; No. 4 attends only to the injured limb. No. 1 now commands: 2. LIFT PATIENT; when the bearers rise slowly and, when upright, as shown in fig. 91, at the command, 3. *Forward*, 4. MARCH, they move by short steps until the head of the patient is over the pillow on which it is to rest. No. 1 then commands: 1. *Squad;* 2. HALT; LOWER PATIENT; when the bearers slowly lower the patient on the litter.

Or the commands for marching and halting may be omitted, the bearers standing fast while No. 1 slips the litter under the patient.

Nos. 1 and 4 now see that the patient is in a comfortable position and perfectly secure, the head properly supported and the wounded part so placed that it can be easily attended to on the march.

The movements on the loaded litter are executed in accordance with the commands of the hand-litter drill as stated above.

It will be observed that, in raising the patient to the litter by this method, the head and upper part of the body are considerably elevated. An individual who is intensely prostrated may not be subjected to this treatment without risk of syncope. In such cases the following method is recommended by Smart:

When the litter has been halted near the head or foot of the patient, and in line with his body, No. 1 commands: 1. *Stand to wounded;* 2. *Right* (*or left*); 3. MARCH. If *right* has been ordered, Nos. 2, 1 and 3 proceed by the right of the litter and range themselves along the corresponding side of the patient, facing him—No. 2 by his right knee or left shoulder, according as the head or feet of the wounded man point to the litter, No. 1 at his hip and No. 3 at his right shoulder or left knee, while No. 4 takes position opposite and facing No. 1. If left has been ordered, Nos. 2, 4 and 3 proceed by the left of the litter and range themselves along the corresponding side of the patient, while No. 1 takes position opposite to and facing No. 4. The accompanying diagram shows the positions of the bearers when the order is right (fig. 93). At the command, LOAD—using the numbers for the movement, *one*, the bearers kneel on the right knee if on the right, and on the left knee if on the left of the patient; *two*, No. 2 or 3, who is stationed at the patient's knee, passes both arms about the patient's legs, carefully supporting the fracture, if there be one, Nos. 1 and 4 pass their arms under his hips and loins, No. 2 or 3 passes one arm under his neck to the farther axilla, with the other supporting the nearer shoulder; if possible the patient clasps his arms about the neck of this bearer; *three*, all lift together, slowly, supporting the weight upon their knees, and as soon as the patient is firmly supported, No. 1 or 4, whichever is on the free side, withdraws his arm and passes by the shortest line to the litter, which he takes up near the middle, one pole in each hand, and returning to his

position, places it under the patient and close against the bearers, being careful to see that its legs are properly arranged, and then assists, as before, in supporting the patient; *four*, all the bearers gently lower the patient on the litter; *five*, the bearers rise and resume their position, 2 and 3 as carriers, and 1 and 4 on the right and left of the litter, respectively.

It will frequently occur that, being wounded in the leg or foot too severely to walk, the injured man can, nevertheless, with proper attendance, seat himself upon the prepared litter placed by his side and then lie comfortably upon it.

To change bearers on the march, No. 1 commands: 1. *Litter;* 2. HALT; 3. LOWER LITTER; followed by 1. *Change Posts;* 2. MARCH; when Nos. 1 and 2, and 3 and 4 exchange posts and duties, except that No. 1 retains command of the stretcher.

The transfer from litter to litter, or to bed, is effected in the same way as from the ground to the litter, the bearers always observing, as far as practicable, that the litter or bed to which the patient is to be transferred shall be at the head of the patient, its length in the direction in which he is lying.

As a general rule in hand-litter operations, the feet of the patient should point in the direction in which the litter is carried. But in going up hill or upstairs, the patient's head should be in front, unless he has a broken leg or thigh, in which case the order is reversed to prevent the weight of the body from pressing down on the injured part; and on the going down hill, the patient's head should be behind, except for the reason given in cases of fracture of the lower extremities. It is important that the bearers should keep the litter level, notwithstanding an unevenness of the ground. In making ascents, the stronger of the two bearers should be in rear, as he has to bear a greater weight in raising his end of the litter to the proper level, and in making descents he should, for the same reason, be in front. A breach should be made in a fence or wall for the passage of the stretcher, if there be no gate or other opening, rather than risk the passage of the injured man over it; but should it be necessary to surmount the obstacle, Nos. 1 and 2 place the front handles securely on top, while 3 and 4 elevate the rear handles; the two first-mentioned then cross the wall and advance the litter until its rear handles rest upon it, when 3 and 4 cross, resume the handles, and all lower the litter, after which the march is continued as before the obstacle was reached.

In crossing a ditch or deep cut, the litter is laid on the ground with the front handles near the edge; Nos. 1 and 2 descend and advance the litter, keeping it level, until the rear handles rest upon the edge, when Nos. 3 and 4, who have assisted in this movement, descend and resume the support of their respective handles; the ascent is made on the other side by Nos. 1 and 2 resting their handles on the edge, ascending and advancing the litter until its rear handles rest upon the edge, when Nos. 3 and 4 ascend and the march is resumed. The position of a patient on the litter depends on the site and nature of his injury. The head should be, as a rule, low, particularly when the patient is faint; but difficulty of breathing in penetrations of the chest often requires that the head and shoulders be elevated. In wounds of the abdomen the best position is on the injured side, or on the back if the front of the abdomen is wounded; the legs in either case being drawn up and a pillow or other suitable object placed behind or beneath the knees to keep them bent. In an injury of the upper extremity, calling for litter transportation, the best position is on the back or on the uninjured side, while in injuries of the lower extremity the patient should be on his back or inclining towards the wounded side.

To change the direction of the litter in order to ascend an elevation, when the patient's lower limbs are not fractured, or to descend an elevation when such a fracture is present, No. 1 commands: 1. *Squad;* 2. HALT; 3. *Lower litter;* 4. *About* FACE; 5. *Raise litter;* 6. *On* No. 2 (or 3) *right* (or *left*) WHEEL.

To fold the litter when the patient has been disposed of and the necessity for the open litter is at an end, the squad being at their posts, No. 1 commands *Fold* LITTER; when 1st, No. 2 steps to the outside of his right handle, No. 3 to the outside of his left handle, and all face the litter; 2d, Nos. 1 and 4 advance to mid-length of the litter, bend on the knee, grasp the litter with hands under poles and rise erect, holding the litter horizontal; 3d, Nos. 2 and 3 remove slings from handles and lay them across litter near its ends, close handles, legs and transverse irons, fold canvas lengthwise on top of poles, placing slings lengthwise on canvas, buckles out, and securing all by straps at ends. The litter is then lowered. At the command *Lower* LITTER, Nos. 1 and 4 lower the litter on the ground, handles on the right of Nos. 2 and 3, and recover the erect posture. The command *To your posts*, MARCH, brings the

squad to the position occupied before the litter was unfolded, after which, at the command *Front into line*, MARCH, 1, 3 and 4 advance to the line of No. 2 in their regular formation, 1, 2, 3 and 4 from right to left. The squad may then be rested or marched off in any direction without the litter or with it.

The foregoing description of the stretcher drill, adopted by our army, taken from Dr. Smart's "Handbook for the Hospital Corps," shows the drill to be simple, to the purpose and devoid of all unnecessary frills.

The adoption of the bearer drill of our army by the Navy would seem desirable from many points of view, but more especially so in the not impossible event of future co-operation of both branches of the service.

The stretcher is, fundamentally, the most important piece of apparatus used in the transportation of the wounded, whether on board ship or on shore. All other means of conveyance must be considered merely as modifications of the regular stretcher, and any one expected to improvise and extemporize means of conveyances for the sick and wounded in time of scarcity and need, must first have been made familiar with the principles underlying the practical management and construction of the stretcher, no matter what its form or description.

For use on shore and in hospitals the plain, ordinary stretcher, provided with legs, will always be found to be the best and most convenient as well as the safest means of conveying the sick and wounded. Such a stretcher can be carried by two men either by hand or by means of shoulder straps, the ends of which are slipped on to the handles. A change of bearers is easily effected and without having to lower the patient flat on the ground, which may be rough, uneven or wet. During all naval operations on shore, therefore, such stretchers, provided with legs to stand on, should, if possible, be used, and other means of conveyance extemporized when a sufficient number of regular stretchers are not at hand.

For purposes of handling and transporting the sick and wounded on shipboard several very ingenious cots have been designed.

Fig. A represents the ambulance cot invented by Dr. A. L. Gihon, U. S. N., with patient in position and ready to be lowered either into a boat or through a hatchway. As seen in the figure,

the cot consists of a wooden frame with a sheet of canvas stretched across, and with a number of canvas bands of different widths sewed on so as to secure the patient in position and prevent his slipping out in case of accident while being lowered through a hatch or down a ladder.

In cases in which the injury would be such as to necessitate the patient's being passed down a ladder head foremost, the shoulder straps can be easily and effectually so arranged as to prevent the patient from slipping in this direction also. Gihon's cot, therefore, seems to me a perfectly safe one and well adapted for use on board ship.

Fig. B shows the cot designed by Dr. A. C. Gorgas, U. S. N., in position and ready to be lowered.

As seen in the diagram, the thighs and legs of the patient are resting upon a leather-covered, double inclined plane which can be moved and adapted to suit the requirements demanded by special cases, while a narrow leather band is made to hold the upper part of the body in position and prevents it from slipping in a downward direction.

The so-called "Rapid Transit Ambulance Cot," made by the Walton Manufacturing Co., of New York, and invented and patented by Dr. H. M. Wells, U. S. N., is another very good cot for purposes of moving patients on board ship. This cot is constructed of stout canvas with thin hickory slats stitched in across the bottom, which give it sufficient stiffness laterally and permit it to adapt itself longitudinally to the form of the patient.

There are ten stout canvas handles on the sides for lifting, and the cot may either be carried straight or at an angle, as may be required by the particular disability of the case. It is also narrow enough to be passed down any ladder or along any gangway, and has no lateral projections; it can also be slung by the handles and raised or lowered by pulleys through any hatch.

Fig. 94, A, represents the cot rolled up, weight 10 lbs.; B shows how a patient may be carried at an angle; C, cot without poles; D, cot with poles.

The cot suggested by Lieut. T. B. M. Mason, U. S. N., belongs to the class of *extemporized* cots and simply consists of an ordinary ship's hammock stretched across and secured to a wooden frame. There are, indeed, times when no one single ready-made conveyance will answer the purpose and when a special one must be improvised.

FIG. 92.—Showing correct manner of clasping hands.

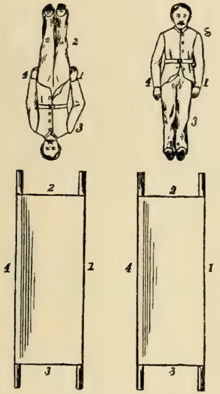


FIG. 93.—Standing to wounded by right.

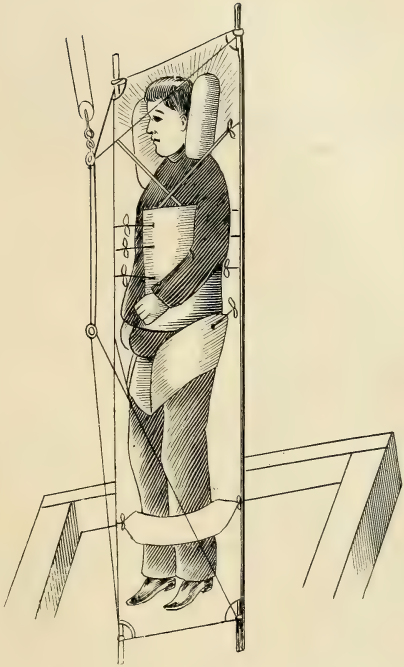


FIG. A.—Gihon's cot for ship's use; patient ready to be lowered through a hatch or into a boat.

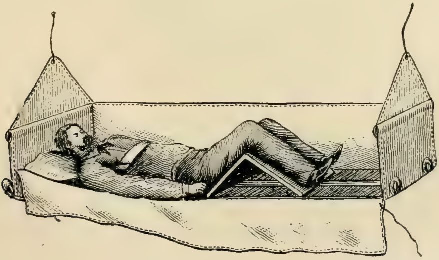


FIG. B.—The Gorgas cot.

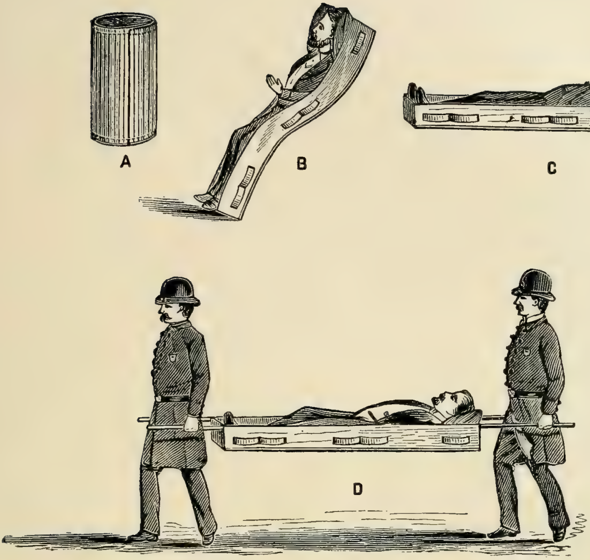


FIG. 94.—The Walton-Wells cot.

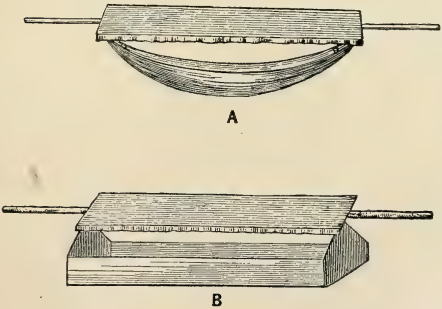


FIG. 95.—Extemporized cots.

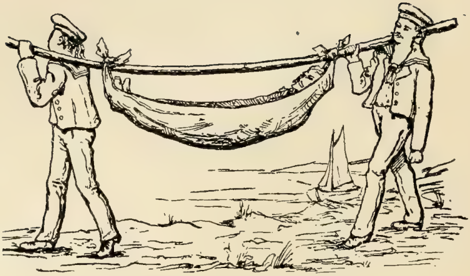


FIG. 96.—Extemporized cots.

FIG. 97.—(Notes in text.)

Hammocks and cots are always plenty on board every ship, and these may easily be converted into ambulance cots by being suspended from single poles, as shown in figs. 95 and 96, or they also may be changed so as to be carried between two poles.

The former plan was adopted during the late expedition of British troops in Western Africa, and Staff Surgeon H. Fegan, R. N., mentions that each hammock was fitted with a pillow made of another spare hammock, which in the event of an emergency could be easily slung from tree to tree and thus often proved very useful.

Any blanket, bed cover, traveling-rug may be converted into a hammock, as shown in figure.

For purposes of embarking or disembarking the sick and wounded where stretcher conveyance is not available or inapplicable, Dr. J. D. Macdonald, F. R. S., R. N., has designed an "ambulance lift" for ship or shore, seen in the accompanying figure.

Fig. 97.—Ambulance Lift for Ship or Shore.—References to the Figure.

1. Hook or eye-bolt fixed to the beam over the hatchway.

2. A "double whip" or a purchase with a double block above and a single one below, *a* and *b*; *c*, the hauling part.

3. A span with an eye in the middle for the lower hook of the purchase.

4. A pole, 4½ feet long, with which the span is connected.

5. An ordinary hammock attached by the head and foot clews to the extremities of the pole and further sustained by lanyards, *a*, fixed to a hand piece, *b*, besides the leg. In cases such as these the cacolet bed has rendered excellent service. In order to prevent the shaking as much as possible it is desirable to make the patient sit or lie on pliant cushions, and for this purpose India rubber ones are recommended, which have frequently been made use of.

Two rifles and one or two coats, the sleeves turned in, make a very good temporary stretcher. The present working suits of our sailors used in the same way with two boat-hooks, would make a very solid stretcher, as will also several knapsacks or sword-belts. Figs. 98 and 99.

The means that are employed in making extemporaneous cots and stretchers must, of course, at all times depend upon where the accident will find you. The more thoroughly you are familiar with the principles of your work, with the aim and object you have in view, the more readily will you find such means as will answer your purpose.

Practical Exercises: Stretcher drill and extemporizing ambulance cots.

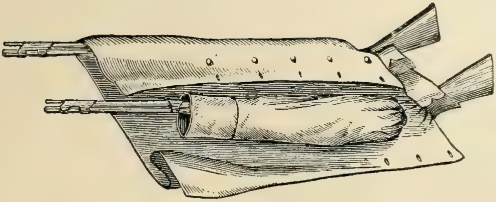


FIG. 98.—Extemporized stretcher.

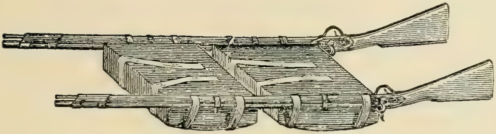


FIG. 99.—Extemporized stretcher.

FIG. 100.—Modified Indian travois for transporting the sick or injured over rough and mountainous roads.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1893.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules :

1. The award for the Prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1893. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control ; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

H. S. KNAPP,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *March* 15, 1892.

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CONTENTS.

No. 64.

THE PROCEEDINGS

OF THE

CORRIGENDA.

Page 546, line 24, for *dynamite* read *dynamic*.
Page 588, line 5, the sentence should read: *A foot-pound is equal to twelve pound-inches, or twelve thousand pound-thousandths-of-an-inch.*

NAVAL SIGNALING.

By A. P. Niblack, Lieutenant, Junior Grade, U. S. Navy.*

It is not proposed to here touch upon the history of signaling, nor to consider the question of interior communication aboard ship, viz., by annunciators, voice tubes, bells, etc. It is the plan to first point out the limitations which affect and control the methods of communication which are available under different conditions, and from a consideration of these to show wherein naval signaling differs in principle from army signaling. We will next take up the consideration of signal codes in use in different military organizations at home and abroad, and from them deduce the theoretical principles which should determine the choice of such codes. This involves a discussion of the concessions which theory must in certain cases,

* Subject to examination.

THE PROCEEDINGS

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NAVAL SIGNALING.

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It is not proposed to here touch upon the history of signaling, nor to consider the question of interior communication aboard ship, viz., by annunciators, voice tubes, bells, etc. It is the plan to first point out the limitations which affect and control the methods of communication which are available under different conditions, and from a consideration of these to show wherein naval signaling differs in principle from army signaling. We will next take up the consideration of signal codes in use in different military organizations at home and abroad, and from them deduce the theoretical principles which should determine the choice of such codes. This involves a discussion of the concessions which theory must in certain cases,

* Subject to examination.

and for certain good reasons, make to practice as brought out by actual trial in service. The methods of army signaling are touched upon only to illustrate the difference in principle. The different methods of signaling at sea in use in our own and in foreign navies are then taken up and discussed in detail. However meagre the data on which are based the conclusions here set forth, enough is presented to show that there are certain definite principles which must be adhered to in the formation of a code, or the design of any sort of an apparatus or method of transmitting it.

In the navy we have in a measure been dominated by the army. This influence dates back to the Civil War. The Myer signal code was invented by the late Brigadier-General A. J. Myer in 1856, and was first reported on favorably by a board of army officers in 1858. In 1860 Myer was appointed chief signal officer of the army, and ordered West on Indian campaign duty. Many of the officers and men whom he then instructed and organized into a signal corps went South on the breaking out of the Civil War. This resulted in the Myer code being used with conspicuous success on both sides. It was also adopted in the navy, but even in such important operations as those in Mobile Bay we had army signalmen aboard all our ships to receive and transmit messages. It remained the army and navy code until April 3, 1886, when it was unwisely superseded by the Continental Morse, which was in January, 1890, itself more unwisely succeeded by the American Morse code. It was the genius of Myer which first organized and perfected the signal corps of our army, and which first demonstrated the value of rapid and accurate communication in extended operations on shore. Since his death we have gained nothing from the army in the matter of signaling.

In recent years the addition of the duties of the weather bureau to those of the signal corps has done much to overshadow the importance of signaling as an art in itself. Since the Civil War the navy, in squadron cruising, has had daily practice in signaling of all sorts, and we now have sufficient experience to qualify us to judge for ourselves of our own needs. It will appear further on that some of the conditions of signaling in the navy are widely different from those governing army practice. We have, therefore, ample data upon which to strike out for ourselves in this important matter.

In the discussion of signal codes in general, the following tabulated synopsis will outline briefly the method here presented:

- SIGNAL CODES.
  - LIMITATIONS.
    - DISTANCE.
      - Ordinary.
      - Long.
    - METEOROLOGY.
      - Day.
      - Night.
      - Gales.
      - Fog, mist, rain or falling snow.
      - Refraction, etc.
    - TOPOGRAPHICAL.
      - LAND.
        - Desert.
        - Woods.
        - Hills.
        - Valleys.
        - Mountains.
        - Water.
      - SEA.
        - Rough.
        - Dip of horizon.
    - ENEMY.
      - Ordinary communication cut off by enemy or by smoke of battle.
  - ELEMENTS.
    - NUMBER OF—
    - KIND.
      - Sound.
      - Time.
      - Motion.
      - Color.
      - Form.
      - Position.
    - GROUPS OR CHARACTERS.
      - Alphabetical.
      - Numeral.
      - Special.
    - DISPLAY.
      - Transient.
      - Permanent.

We start first with the limitations of signaling in general.

Rapid and accurate communication between the different parts of organized military forces, both afloat and on shore, is of vital importance. The limitations of military signaling in general are, roughly speaking:

1. *Distance.*—At sea the dip of the horizon limits the range of signaling, and mechanical difficulties add greatly to the problem. On shore modern inventive genius has in a measure solved most of the problems of distance by the use of telegraphy and heliographing for military signal purposes, while both afloat and ashore carrier pigeons offer a restricted field of usefulness.

2. *Meteorology.*—Fog, mist, rain, falling snow, gales of wind, and the conditions of the atmosphere as regards refraction, etc., affect materially the methods which are available for communicating or signaling. Under this head we may also classify daylight and darkness, that is day and night.

3. *Topography.*—The character of the land or water, hills, valleys, mountain ranges, deserts, woods, etc., determines also the character of the methods we may use in communicating. At sea the chief limitation of topography is the dip of the horizon, which is in itself one of the restrictions imposed by distance.

4. *The enemy.*—In time of war the presence of the enemy in force between signal stations, the smoke of action, and the exigencies of battle may require the use of special methods of communication; for instance, in the recent labor troubles at Homestead, Pa., the militia surrounded the steel works, one division being encamped on the opposite side of the river. Owing to the smoke from the mills and the vigilance of the strikers, ordinary communication with wig-wag flags or telegraph was cut off between the two main divisions of the militia. The heliograph was brought into use and the reflected sunlight readily pierced the smoke, and messages were read without difficulty.

On shore to communicate rapidly and accurately, four methods are available under some one of the above limitations, viz.:

1. *Messengers.*—Messenger service is here taken to include all means of sending a verbal or written message by a bearer; for instance, by an orderly mounted on horseback, or bicycle, or in some vehicle of transportation, such as a wagon, railway or balloon. It also includes pigeon service, which is a valuable adjunct to any means of day communication.

2. *Visual signaling.*—This includes all methods of transmitting a prearranged code by the motion of some object, by the display of certain symbols, shapes, or lights, or by the flashing of light.

3. *Phonetic signaling.*—In this the same object is accomplished by the emission of sounds of different characters; as, for instance, by gun-fire, bugle, bell, drum, gong, whistle or siren.

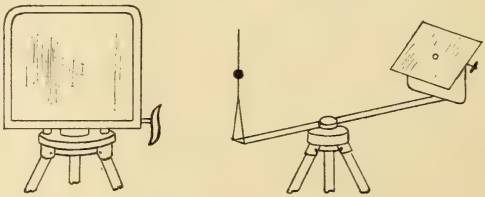
4. *Telegraphy.*—With a well organized field corps, and an outfit including wires, transmitters, poles, wagons, batteries, telephones, balloons, etc., we have in telegraphy the highest development of military signaling.

At sea the conditions are somewhat different. Dispatch vessels and the other auxiliaries of a fleet carry messages, and the pigeon service has a more limited application than on shore. Visual and phonetic signaling are, however, admirably adapted to naval uses, but telegraphy between vessels is as yet not feasible, although telegraphy by induction at sea has passed its earliest experimental stages and may be perfected in the course of a few years. However, at the best its range will be short and its usefulness restricted to less than long visual distances. In other words, telegraphy and heliographing from high stations, combined with balloon and pigeon service, give a very long range of communication on shore; at sea the curvature of the earth, the absence of elevated stations except by captive balloons, the impracticability of telegraphy and distant heliographing, all combine to restrict the range of signaling, and, as before stated, make the problem of distant signaling at sea one of the hardest to solve.

It would seem that army and navy signaling should involve the same underlying principles, but, curiously enough, the development has been along such radically different lines that the fundamental principles are surprisingly different, at least as between the methods used in our own army and navy. In the army the principal methods used are the wig-wag, the telegraph and the heliograph. These cover nearly all the conditions of strict signaling, as at night the torch is used with the wig-wag and a flash light with the usual type of lantern and shutter. These methods all aim at communication with only one station at a time, that is to say, to wig-wag, telegraph, or heliograph from one station to another. All around visibility or audibility is not a factor. In the navy we have sought and are seeking the development of methods which give visibility all around the horizon, so that a squadron can see the signals from any direction. Later on, in the consideration of the theoretical principles of naval signaling, it will be shown that the objections to

flags and to the semaphore are largely that they do not possess this virtue of all around visibility. It is very important, therefore, at the very beginning of the consideration of naval signaling to point out the capital error of adopting army codes and methods in our navy.

Let us first take the heliograph. In our western territories, during several Indian campaigns, the heliograph was used most successfully. In the military department of Arizona from November, 1889, to May, 1890, a chain of heliograph stations 2000 miles long was maintained in Arizona and New Mexico, completely networking the country in which the hostile Indians usually operated. The main stations were on mountain peaks, some 8500 feet above the sea level, and were from 50 to 100 miles apart. Connected with these were numerous secondary stations, forming a complete network over the territory embraced in the main lines of communication, so that any movement of the hostiles was rapidly reported to headquarters. The entire scheme was under the management of and developed by Col. W. J. Volkmar, U. S. Army, of the Adjutant General's Department. Two sizes of mirrors were used, 4½ and 8 inches square, for short and long ranges respectively, although the smaller size was successfully used on the long ranges. These were mounted on one end of a sighting arm that was itself mounted at its middle point on an ordinary



tripod. Through a small unsilvered spot in the center of the mirror, this arm could by the eye be pointed at any station and clamped in position. On the end of the sighting arm opposite the mirror, sliding on a vertical sight-bar or rod, was a small round disc. To adjust the instrument on the distant station, the disc was moved up or down so as to just mask the view of the station from the eye at the unsilvered spot on the mirror. The mirror was

capable of a slight lateral motion on its horizontal axis by means of a tangent screw, and of a revolving motion around the said horizontal axis. The object of the disc and of the unsilvered spot on the mirror was that when the unsilvered spot cast its shadow, so to speak, on the disc in front of it, the full beam of reflected light from the mirror was on the distant station. This enabled an assistant operator, by adjusting the axis and turning the mirror gradually, to follow the sun in its change of altitude and azimuth, and to keep the beam of light constantly on the distant station; for all he had to do was to keep the disc unilluminated by the unsilvered spot. Some three feet in front of the mirror was another tripod carrying a vertical shutter or screen, operated by a lever so as to fall flat or rise to a vertical position at the will of the operator. This shutter, when vertical, masked the beam of light thrown by the mirror towards the distant station, and by working it the beam could be flashed on the dot and dash system, using the Morse code. To call the distant station the beam was turned on steadily till answered. If at any time the sender's mirror got out of adjustment so that the distant station failed to see it during the course of a message, the distant station turned on its beam of light to stop the message till re-adjustment was effected. So successfully was this means of communication operated that, on May 14, 1890, partial communication was established between the stations on Mt. Graham and Mt. Reno, a distance of 125 miles. Two stations with one intermediate covered 195 miles. Constant communication was kept up between Mt. Graham and Lookout Peak (Sierra Anchas), 105 miles distant, and between Mt. Graham and Fort Huachuca, a distance of 90 miles. The altitude and the remarkable clearness of the atmosphere were, of course, favorable to such remarkably long ranges. As previously noted, the heliograph was used this summer at Homestead under peculiar circumstances, illustrating its value in smoky weather and with stations separated by the enemy.

The navy has blindly followed the army in the matter of signal codes ever since the Civil War. In all the three codes which we have gotten from this source, viz., the Myer, the Continental Morse, and the American Morse, we have copied the instructions for heliographing as if we seriously contemplated using this method. Heliographing is not possible from one ship to another, nor from a ship to the shore, nor from the shore to a ship. Absolute immobility is

required in the receiving and transmitting stations. This we do not get in either a ship at anchor or underway. Heliographing from its name implies the use of the sun's rays. It is a method of visual day signaling. It is adapted to high altitudes where the disturbing effects of refraction and the convection due to heat rays is inconsiderable. Along the coast at the sea level it has a most limited range of usefulness. It is essentially not adapted to naval purposes. What we use and what we want is a flash light or lantern, which is a very different sort of an affair, as it gives visibility all around the horizon. Of couse it is well enough to know how to use a heliograph in the navy and how to signal with one, for they are useful in triangulating work, such as is done on the coast of lower California and Mexico, but, as a method of naval signaling, heliographing is not especially useful in cruising.

The army, in June, 1889, adopted for signaling the American Morse code in place of the Continental Morse. It is as follows:

Army and Navy Code for Visual and Telegraphic Signaling.

American Morse Alphabet.

A - —	F - — -	K — - —	P - - - - -	U - - —
B — - - -	G — — -	L ——	Q - - — -	V - - - —
C - - -	H - - - -	M — —	R - - -	W - — —
D — - -	I - -	N — -	S - - -	X - — - -
E -	J — - — -	O - -	T —	Y - - - -

Z - - - -   & - - - -

Numerals.

1 - — — -	3 - - - — -	5 — — —	7 — — - -	9 — - - —
2 - - — - -	4 - - - - —	6 - - - - - -	8 — - - - -	0 ———

Punctuation.

Comma - — - —	Interrogation — - - — -	Parenthesis Pn
Semicolon S,	Quotation Qn	Bracket Bx
Colon Ko	Paragraph — — — —	Dollar Mark Sx
Period - - — — - -	Exclamation — — — -	Dash Dx

Hyphen Hx   Underline Ux

Note.—A fraction is made by inserting a dot between the numerator and denominator. Example: $\frac{7}{8}$, — — - - - — - - - -

The reasons which led up to this change were good and sufficient ones, considering the problem solely from an American standpoint. We have no military telegraph lines to speak of, and in any operations in our own country, as, for instance, in recent Indian wars, messages must be sent over commercial lines. The operators are skilled in using only the commercial code, and, besides the vast number of operators offers an inexhaustible supply on which to draw in time of war. The many theoretical and practical defects of this code are gotten around the best way possible in the wig-wag and by the heliograph for the sake of the advantage the code offers in telegraphy. Now, from a naval standpoint, no advantage accrues to us from adopting such a code. We do not want telegraph operators on board ship; we have no signal corps to recruit, and we have no telegraph lines.

This code was invented before the principles of signaling were at all understood, and has been in use so long that it is now impossible to either correct its defects or substitute any other for it. The best military codes have only two elements. The American Morse has four, viz., the dot, the dash, the long dash, and the space. When this is transmitted by a wig-wag flag or a torch, the dot is a motion to the right, the dash is a motion to the left, the space is a motion to the front, the long dash is made by pausing in the motion to the left and holding down the flag or torch for a preceptible interval; the "front" or space between words is made by introducing a slight pause before and at the end of the front motion to distinguish between it and the space in the letters c, o, r, y, z and &. In other words, in addition to the elements of motion right, left and front, a pause or element of duration is introduced. This is objectionable, as it brings tension on the eye to catch the pauses, and in long range signaling, when the receiver uses a glass to aid the eye, it is very trying. An alphabet and numeral code require only thirty-six characters. With only five elements in each character, that is a *maximum* of five and a *minimum* of one, *sixty-four* permutations and combinatious of two elements are admissible, yet this code goes to all the trouble to introduce characters containing six and seven elements, and that, too, with four fundamental or unit elements to build upon. Using the four units, the theoretical number of possible permutations and combinations, with one as a *minimum* and six as a *maximum*, is 5460. However, as the space

can only come between the other elements, the practical number is much smaller, but still the three or four thousand possible, and the need for only some forty or fifty characters at the most, show how little theory entered into the considerations when the American Morse code was invented. The army may be able to put up with the many defects of this code in consideration of the other advantages which come with it, but for naval purposes the needs of a code cover a much wider range and impose most trying conditions. For instance, in the wig-wag, unless the sender is facing the receiver squarely, the space motion in the letters will invariably be taken for a dot or dash (according to circumstances). On shore, in communicating between stations, there is no difficulty in facing squarely. Afloat, on board a rapidly moving torpedo-boat or a vessel turning, the sender cannot always face the receiver squarely, particularly if sending to two or more vessels or receiving stations which are not close together. With a telegraph key and sounder which works quickly, the space is rather short, and rapid signaling is possible. Using a fog-whistle or an electric light to transmit this code, the slowness and deliberateness which must be used makes it necessary to prolong the element, as will be hereafter explained. The time elements of space and long dash add much to making this the slowest code invented. Practically on the fog-whistle this code is transmitted as follow: the dot is a short toot, the dash is a blast of at least two or three seconds, the space is a blast of five to ten seconds, the long dash is a blast of ten to fifteen seconds. Failure to distinguish between the long dash and the space letters leads to confusion in distinguishing the space letters, c, o, r, y, z, and &, from syllables containing the letter "l," such as ele, eli, ili, ile, sle and els. The time consumed is enormous. To make signal for a simple change of course requires some five minutes, during which time the blasts are almost continuous, approaching vessels cannot be heard, the people on the bridge are deafened, and the vessel itself is positively a danger to navigation. In some such system of night signaling as the Ardois or similar apparatus used abroad, there is no way to transmit the space letters, and a hoist of six lanterns is required to transmit the numeral *six*. As we are the only navy that uses as many as five lanterns, six would, indeed, be a step backwards. As a matter of fact, the American Morse code cannot be used on the Ardois, and in our service we have a special code called the

"Ardois" to use with the apparatus. These criticisms are only meant to bring out strongly the important fact that it is not safe to violate the fundamental principles of signaling in the construction of a code. There *are* principles in signaling and it is now proposed that we take up the theory of signaling and work out those principles, testing them afterwards by the conditions imposed in actual service. It is certainly unsafe for us to be guided by the conditions which determine the selection of a code by the army, when the objects to be sought and the topographical and meteorological conditions are radically different. The simpler the whole question of signaling can be made, and the fewer the codes which men have to learn, the better we will get along, as we have no corps of trained signalmen and we require practically all our officers and men of the active combatant force to be up on signaling.

The Theory of Signaling.

Signaling is the transmission of a prearranged code as accurately and rapidly as mechanical or other means will admit. All signals or codes are prearranged or preconcerted. The simplest are those of one element where the display of a certain motion, sound or symbol, a certain number of times or under certain circumstances, is taken by previous agreement to have a special meaning. For instance, a lantern, a handkerchief, a hat, or anything by which the attention is attracted. In codes of more than one element the elements are color, motion, sound, time, form or position, grouped to represent special characters, letters or numerals, or all three. The characters, numerals or letters may or may not in their arrangement make direct sense. The key is furnished usually in some book, or else the message is spelled out by means of an alphabet. Signals are of two kinds, *transient* and *permanent*. For instance, motions and sounds are transient because they disappear as soon as completed. Symbols, such as flags, shapes or lanterns, are kept hoisted or displayed till read, and are therefore classed as permanent. It will be found that symbols which answer for short distances generally fail at long distances, so that the question of signaling naturally divides itself into ordinary signaling and distant signaling. From a naval standpoint ordinary signaling is what may be called squadron or fleet signaling, that is, signaling within the limits imposed by squadron or fleet cruising. Under any circumstances a good code

is of the first importance. Expertness comes only with long practice. It is important, therefore, to limit the number of codes which a signalman has to learn to receive and transmit under varying distance, by day or night, or in fog or smoke. The observation of fundamental principles in the formation of a code gives flexibility and reliability.

The simplest military codes in general use are those based on the ten numeral characters. One element may be displayed from one to ten times, or groups of two or more elements, each group representing a numeral character, may be used, or ten different elements may be adopted, each representing a numeral character. One element signaling is too slow. Using ten elements, represented, for instance, by ten flags, gives rapidity, but is more complicated. As a rule, the greater the number of elements the greater the speed in signaling, but the more complicated it becomes, and the greater the mechanical difficulties. Instead of ten flags, we may use, for instance, ten different positions of a semaphore arm, or ten different shapes, or ten different displays of lights, etc. With a semaphore or wig-wag, or display of lights, the numerals of a group or combination are displayed successively, and in some forms of distant signaling the elements of each numeral character are also displayed successively. This is very slow, but the mechanical difficulties and considerations of visibility limit both the number of elements and speed in signaling. With the Very's night code, in which stars are fired from a pistol, the two elements used are red and green. The height to which they go and their visibility makes it a most excellent night code for distant signaling. The use of only two elements, the desirability of groups of four, and the requirement of high firing, restrict the speed of signaling. The code is as follows:

1.	R R R R	2.	G G G G
3.	R R R G	4.	G G G R
5.	R R G G	6.	G G R R
7.	R G G G	8.	G R R R
9.	R G G R	0.	G R R G

Another form of a night numeral code of two elements, in this case white and red, is that used in the German navy with the Conz electric night signaling apparatus. It is as follows:

1.	W	6.	R R
2.	R	7.	W R R
3.	W R	8.	R W W
4.	R W	9.	W W R
5.	W W	0.	R R W

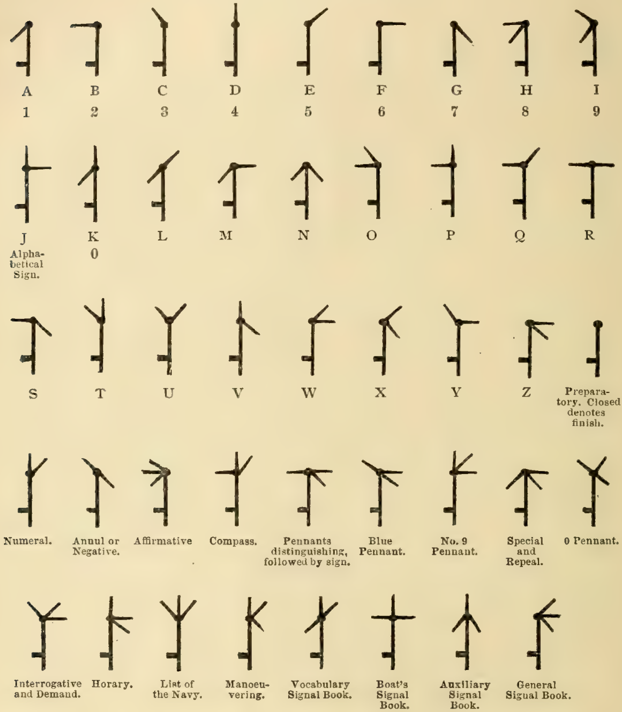
Four other signals, W R W, R W R, W W W and R R R, are used for code purposes.

In flag hoists the signal composed of a group of numerals is made in one hoist, and this gives rapidity in signaling. Limiting the hoist to four, the permutations and combinations, using one, two, three or four in a hoist, is 11,110, which, using code flags to give different meanings to the same display, gives ample range for a general signal book. It has, however, been found by experience that four-flag hoists are difficult to manage in a strong wind, and take time to bend on and hoist. If we limit the hoist to three, the possibilities are only 1110. The Italian naval authorities have adopted the consonants of the alphabet as represented by the eighteen International Signal Code flags. With three as maximum and one as minimum in each hoist, the total number of displays admissible, using the eighteen international consonants, is 6174. The step beyond this is to take all the letters of the alphabet and the ten numerals besides. In English this would give us thirty-six characters, and enable us to spell out any message. The scope of such a code is limitless, but to transmit it by thirty-six different flags is impracticable. In the French Mediterranean Squadron an experimental night code is used which involves two peculiar innovations. The two elements are red and white electric lights. By a make-and-break key these lights may be called flashing. This gives four elements in reality, a fixed white, a flashing white, a fixed red and a flashing red. As in our Very night code, the groups are each of four elements. If any display contains less than four elements, there is a mistake and the signal is disregarded.

In a semaphore code the elements are those of position, and each letter is displayed transiently in one motion. This gives great speed, but limits the code to visual signaling. There is no way of transmitting it phonetically or by flash. The night semaphore, using arms illuminated with lights or lighted up by reflection is not regarded as at all satisfactory. Many experiments have been made in the English navy, but the result is that the Continental Morse code is

used with a flashing or winker light, transmitting the dot and the dash. The English semaphore code is as follows:

ENGLISH SEMAPHORE CODE.



To construct an ordinary alphabet and numeral code two elements are used, and these are combined into thirty-six or more different characters. Two elements, limited to four as a *maximum* in any combination and with one as a *minimum*, give a possibility of only thirty different characters. With five as a *maximum* the limit is

sixty-four, which gives great scope, as only thirty-six are absolutely needed. In a theoretically perfect code of this character, the following conditions should obtain:

1. No elements of elapsed time, or duration, and no elements requiring a pause should be used, as the tension on the eye, ear, and brain is very trying.

2. Transient elements, such as those of motion, give speed in signaling, and are better than time elements.

3. Two elements, limited to a maximum of four in each combination to represent a letter, give the best results.

4. The vowels and letters which are on the average most often used should be selected from the simple elements or combinations having the fewest elements, in order to give speed in signaling.

5. Groups of symbols, representing words or complete phrases and sentences, should be separated by a positive character or symbol, instead of by a pause or time element of duration.

6. The numerals should all have the same number of elements in the combinations representing them.

7. No numeral signal should be made as such, without a distinctive signal "Numerals follow," and, on the completion, one implying "Numerals end."

These principles here enunciated may not, on grounds of expediency, be best in some particular method of signaling, but, for a general code adapted to all conditions, they will be found fundamentally sound and safe to build on. So many mechanical means of transmitting signals have, from time to time, been invented and tried, and each new invention has seemed to treat the theoretical requirements of a code with less and less consideration, that the result is theoretical considerations are either little understood or never heeded. Many of these mechanical devices are extremely valuable, but it should not be lost sight of that a good code is of the first importance, and the mechanical means of transmitting it is in a sense secondary. No change in a good code should be made simply for the sake of adopting a good mechanical means of transmitting it, unless the reasons therefor are of the utmost importance.

The simpler the question of signals can be made, and the fewer the number of codes that have to be learned, the less training signalmen will require, and the greater the number of officers and men that can become proficient. There is, of course, such a thing as sacri-

ficing too much to simplicity, but if one code can be made to answer for all the devices required for squadron and distant day, night, and fog signaling, then it is reasonable to expect that every officer and man in the combatant force shall know that one code thoroughly.

The two best known and most thoroughly tried military signal codes in the world are the Continental Morse and the Myer. The Continental Morse is in general use in Europe, and is as follows:

Continental Morse Alphabet.

A · —	G — — ·	M — —	S · · ·
B — · · ·	H · · · ·	N — ·	T —
C — · — ·	I · ·	O — — —	U · · —
D — · ·	J · — — —	P · — — ·	V · · · —
E ·	K — · —	Q — — · —	W · — —
F · · — ·	L · — · ·	R · — ·	X — · · —
	Y — · — —	Z — — · ·	

Numerals.

1	2	3	4
· — — — —	· · — — —	· · · — —	· · · · —
5	6	7	8
· · · · ·	— · · · ·	— — · · ·	— — — · ·
	9	0	
	— — — — ·	— — — — —	

In this code the distinction between the elements dot and dash is one of duration. The interval between the words is a pause. In transmitting it by a wig-wag flag or a torch, the dot is a motion to the right, the dash is a motion to the left, and the pause or time interval representing the space between words is a motion to the front. In other words, time elements of different values are transmitted by motions of equal value in point of time of making them. With the heliograph or winker light or on a fog-whistle, the dot and dash are distinguished by the greater duration of the dash. On the Ardois or Kasolowski, or similar system, the dot is a red and the dash a white light. By gun-fire the dot is transmitted as one gun a dot, two successive guns a dash. There is no positive character or "front" separating words and sentences, or groups of numerals, but a pause or element of elapsed time is used instead, which is one of the few defects of the code.

The Myer code is as follows:

Myer Code.

A	2 2	H	1 2 2	O	2 1	V	1 2 2 2
B	2 1 1 2	I	1	P	1 2 1 2	W	1 1 2 1
C	1 2 1	J	1 1 2 2	Q	1 2 1 1	X	2 1 2 2
D	2 2 2	K	2 1 2 1	R	2 1 1	Y	1 1 1
E	1 2	L	2 2 1	S	2 1 2	Z	2 2 2 2
F	2 2 2 1	M	1 2 2 1	T	2	End of word	3
G	2 2 1 1	N	1 1	U	1 1 2	End of sentence	3 3

End of message 3 3 3

Numerals.

1.	2 1 1 1 2	6.	1 2 2 2 2
2.	1 2 2 2 1	7.	1 1 2 2 2
3.	2 2 1 2 2	8.	1 1 1 1 2
4.	2 2 2 1 2	9.	1 1 2 1 1
5.	2 2 2 2 1	0.	2 2 2 2 2

In transmitting the Myer code by means of a telegraph key and sounder, the 1 is a dot, the 2 is two successive dots, and the 3, which is the "front" or interval separating words and sentences, is three successive dots. With the wig-wag, a motion to the right of the sender is a 1, to the left a 2, and to the front a 3. With the flash or winker light by night, or the heliograph by day or night, the 1 is a short flash, the 2 is two successive short flashes, and the 3 three successive short flashes. On the fog-whistle the 1 is one toot, the 2 is two toots and the 3 is three toots. Both the Continental Morse and the Myer codes have really three elements, for in the former the pause or elapsed time between the words is as much a third element as the three of the latter, but the two codes differ radically in their character. The Continental Morse is founded upon three elements, or elements of duration, viz., the dot, dash and elapsed time interval, whereas the Myer elements are those of motion or distant duration. Hence the latter is essentially a wig-wag code, because the motions to the right, left and front correspond to the motions 1, 2 and 3. As to which elements, those of time or those of motion, answer best for naval purposes, the follow-

ing comparison of the Continental Morse and Myer, as representing the best types of each, would seem to indicate that those of motion are superior to those of time. In the wig-wag both codes are transmitted with the same ease and rapidity, and no advantage rests with either. Indeed, as far as construction goes, we might convert one code into the other by making a dot a 1 and a dash a 2. On the fog-whistle it seems more easy and certain to transmit toots than to transmit blasts of varying lengths. A steam whistle, particularly in craft where the steam supply is not great, is not always reliable as to the emission of sounds. In the Myer code the sounds are taken as of equal value, although they may accidently vary in length, and the use of the "front" signal is an advantage, as it relieves the mind of all doubt and embarrassment as to the end of the word, as to abbreviations, as to end of sentence, and as to end of message. It also gives speed in signaling, as there is no need of pausing till the message is ended. Motions or short sounds, in groups of one, two or three, seem to lend themselves more readily to the eye and ear than dots and dashes. This may seem too subtile a distinction, but there are several things to be kept in view from the American naval standpoint. We have no trained signal corps. All the combatant force should know something of signaling. That which appeals to or strikes most readily the untrained eye and mind is best. Simplicity is the first consideration. For fog-whistle and heliographing the advantage in speed of signaling both in theory and practice rests with the Myer. By gun-fire signaling with the Morse code it is necessary to call the dot a 1 and the dash a 2 in order to transmit it, whereas the Myer code is all ready for use and needs no such modification. In naval signaling there can be no question but that the advantage rests with the Myer code as against the Continental Morse. It would be unfair however, not to point out one rather serious defect in the Myer. The front signal 3 is three toots on the fog-whistle and three short flashes by heliograph, which is the same as the letter Y. This leads to confusion, so when this code was in use in the navy the front was made by a blast on the whistle and by a prolonged flash with lights. The Continental Morse has no such "front." To introduce one would require the use of a *long* dash. This is objectionable on the fog-whistle and makes signaling slow. If we convert the Continental Morse into a Myer code by substituting a 2 for a dash, we would still meet with

the same difficulty, as the letter *s* is three dots, and we would have to use a dash for a "front."

The general adoption in the principal navies of the world of some such system of night signaling as the Ardois or Kasolowski apparatus by means of permanent hoists of red and white electric lanterns would seem to call for certain changes in the construction of the Continental Morse and Myer numeral codes, because the lanterns are for certain practical reasons hereafter stated now generally limited in number to four, whereas the Continental Morse and the Myer numerals contain five elements each. The following four-element numeral codes are here proposed to meet this requirement.

For the Continental Morse Code.

1. · · · · or h	6. – – · · or z
2. – – – – or Cornet (genl. call.)	7. · – – – or j
3. · · · – or v	8. – · · · or b
4. – – – · or numeral call	9. · – – · or p
5. · · – – or letter call	0. – · · – or x

Interval · – · –

We might, of course, change the foregoing to a Myer code by using 1 and 2 in place of the dot and dash.

For the Myer Code.

1. 1 1 1 1 or cornet (genl. call)	6. 2 2 1 1 or g
2. 2 2 2 2 or z	7. 1 2 2 2 or v
3. 1 1 1 2 or letter call	8. 2 1 1 1 or numeral call
4. 2 2 2 1 or f	9. 1 2 2 1 or m
5. 1 1 2 2 or j	0. 2 1 1 2 or b

Interval 2 2 1 2

It will be noted that there are only thirty possible combinations of the dot and dash or 1 and 2 limited to four elements as a *maximum*. On the other hand, there are twenty-six letters and ten numerals or thirty-six characters in all, to be provided for. This means that some of the numeral characters must duplicate the letters. In the above arrangements the consonants h, v, z, j, b, p and x are duplicated in the Morse, and z, f, j, g, v, m and b in the Myer

numerals. The intervals • – – • – and 2 2 1 2 occur in neither the alphabet nor in the numeral codes proposed. They separate words, sentences, groups of numerals, etc., and are in other words positive "front" signals. The cornet is the general call to all vessels or stations in sight. When followed by an initial letter it calls a particular ship or station. The "letters call" indicates that the characters which follow are to be read as letters; in other words, as a spelled out message or as consonant signals, as in the International Code. The "numeral call" indicates that the characters which follow are to be read as numerals. It is the "numerals follow" signal, and no character is to be taken as a numeral unless preceded by this numeral call. This is exactly what is done in the English semaphore code. The numerals duplicate letters. The code call "numeral" is displayed when they are meant to represent numerals. It may be thought that in limiting the code to thirty characters too little latitude is allowed for call or code signals, such as telegraph, compass, international, action, etc., and for such special designating characters as interrogatory, affirmative, negative, annulling, preparatory, danger, etc. The following considerations, however, will show that this limitation is largely imaginary. In the wig-wag code all the special significations are provided for in our navy, as follows: The code calls are T. D. U. (telegraphic dictionary use), A. S. U. (action signals use), I. C. U. (international code use), S. B. U. (signal book use), N. L. U. (navy list use), G. L. U. (geographical use), and F. D. U. (fleet drill-book use). These cover all the code calls for all other methods of signaling, except the Very's night code, which is more limited in its scope for reasons hereafter stated, and any number of code calls can be added to cover future contingencies, such as C. A. U. (cipher "A" use), C. B. U. (cipher "B" use), etc. As all other methods of signaling, other than the Very and flag hoists, are alphabetical, the interrogatory, annulling, affirmative, preparatory, etc., can be made by abbreviations, such as "prep." "interrog." or "int." etc. This question will be discussed under each method of signaling, which is hereafter described, as will be also the question as to four lanterns in the Ardois or other night electric code. To summarize, we have in the Myer elements of 1 and 2 two almost perfect elements. Certain modern conditions would seem to demand the use of four elements in the numeral characters. If those conditions are impera-

tive, we can easily accomplish this desired end. If a five element code is thought best or desired most, there is none better, both in theory and as demonstrated in practice than the original Myer code which we gave up in April, 1886.*

SYNOPSIS OF METHODS OF MILITARY SIGNALING.

- METHODS OF MILITARY SIGNALING.
  - ARMY SIGNALING.
    - 1. MESSENGERS.
      - Mounted orderlies.
      - Balloons.
      - Railways, etc.
      - Pigeons.
    - 2. VISUAL SIGNALING.
      - Wig-wag or semaphore.
      - Heliograph.
      - Flash light.
      - Flags and shapes.
    - 3. PHONETIC SIGNALING.
      - Bugle or drum.
      - Gun-fire.
    - 4. TELEGRAPHY.
  - NAVY SIGNALING.
    - 1. MESSENGERS.
      - Dispatch vessels.
      - Pigeons.
      - Balloons.
    - 2. VISUAL SIGNALING.
      - DAY....
        - Ordinary (Squadron).
          - FLAGS
            - International.
            - Naval.
          - Wig-wag or semaphore.
          - Shapes.
        - Distant......
          - Balloons.
          - Shapes.
      - NIGHT.
        - Ordinary (Squadron).
          - Chemical or pyrotechnic.
          - Electric.
          - Flash.
          - Semaphore.
        - Distant.......
          - Balloon.
          - Search light.
          - Chemical (Very's) or pyrotechnic.
    - 3. PHONETIC......
      - DAY OR NIGHT.
        - Ordinary or Squadron.
          - Fog-whistle.
        - Distant........
          - Gun-fire.

* Why the original Myer code was not used with the Ardois apparatus is difficult to conceive. The eight original outfits ordered abroad were marked with what is now called the Ardois alphabet. This has now been perpetuated in six new ones ordered in France, and for all those now contracted for in this country for the vessels building at navy yards. As each apparatus costs fully $1000, it is binding the navy for the future. With all our new ships thus fitted, there is little hope of a return to the Myer code, for it will then be both inconvenient and expensive. The so-called Ardois alphabet violates most of the principles of a good code. A is R W R, B is R W R W, D is R W R W R, H is R W W, O is R R, W is R R R, etc., etc. All alphabetical characters begin with an R (red); all other signals, such as code calls, numerals, etc., begins with a W (white). For instance 1 is W R, 2 is W R W, 3 is W R W R, 5 is W R W R R, 0 is W. This code is unfit for any other purpose. The Myer code would answer just as well on the Ardois apparatus and would be useful for all other purposes.

METHODS OF SIGNALING AT SEA.

The patents taken out in the various countries of the world for devices for signaling at sea would, in their published specifications, fill volumes. Those which have survived the crucial test of actual trial have not been many, but have been sound in principle. Methods which conform to certain conditions are inapplicable to others, so that in naval signaling we have numerous methods. Where one code is utilized for all purposes, expertness is as much a question of ordinary intelligence as it is of practice.

As previously stated, all naval signaling divides itself as to character into two classes, squadron and distant; as to limitations imposed by nature, into day, night, and fog signaling; and as to method, into messenger, visual and phonetic signaling. Distinction is also made as to the relative permanency of any signal displayed—that is, whether transient (disappearing as soon as made, such as a sound) or permanent (displayed until read and understood, such as hoist flags). Bad weather somewhat limits the application and range of any form of signaling. Fog, mist, or snow prevent visual signaling and also some forms of messenger service. Night and day reverse the forms of visual signaling, and distance by day destroys the value of color and increases that of form, whereas by night it increases the value of color and destroys that of form. Experience has demonstrated the value of certain forms and colors for visual signaling and of certain methods for phonetic and flash signaling. Unfortunately the data on which certain recognized standards have been adopted is not available, but an enumeration of the methods of signaling at sea will at least show that it has developed along certain well defined lines.

I.—Messenger Service.

By Dispatch Vessels.—Written messages are sent by dispatch vessels or by the other auxiliaries of a fleet. There are no limitations as to distance. A distinguishing or dispatch flag is usually displayed by such vessel to indicate the character of her mission, and as a notice to others that she is not to be interfered with. Speed and sea-going qualities are, of course, requisite under ordinary conditions of dispatch service, and for distant cruising coal endurance is a prime requisite. The dispatch vessel has been developed as a special

type in most navies, and, as an auxiliary of a fleet, when not employed in carrying dispatches, it is most valuable as a scout.

By Pigeon.—During daylight and for distances not over three hundred miles, communication by pigeon between vessels and the land is quite practicable. Between vessels at sea it has a much more limited application. Such communication is impracticable by night and in a fog, but is not affected by cold, rain or snow, except in the matter of speed. In France satisfactory experiments have been made in communication between ships of a squadron out of sight of each other, and out of sight of land. In the French navy a regular pigeon service has been established and has been used in squadron manœuvres. The birds are taught to alight or set out whilst the guns are being fired, so that they will be available for use in a general action. They know their own ship and fly with as much certainty at sea as on land. Abroad the whole question has passed the experimental stage, and pigeons are used, under certain circumstances, in the French, Italian and Austrian navies. In the United States, satisfactory experiments have been recently made from stations at Newport, R. I., Annapolis, Md., and Washington, D. C. The homing pigeon service, from experiments on the recent cruise of the Constellation, are said to have justified the hope that the service will be officially established in our navy. Several very important messages were sent this summer, and out of twenty-seven birds liberated all but two turned up, and these bore duplicate messages. About September 1, 1892, birds liberated from Fort Monroe covered the distance of 125 miles in excellent time, and all reached their destination. The steamer Waesland liberated a bird 315 miles from Sandy Hook at 1 P. M., and it was in its loft on shore the same evening. When released at sea, pigeons fly direct to land and then take their flight from shore bearings. On shore the longest record of one-distance flight is about 1100 miles, but in these cases numerous birds are let loose, and only a few reach their destination. Forty-six kilometers, or 28¾ miles per hour, is an average long flight, while 1370 yards per minute, or 46 miles per hour, has been recorded in exceptional cases. In Italy regular lines have been established between Rome and Madalena, and between Naples and Cagliari. The former is 150 miles long and averages five hours in flight, and the latter is 280 miles and averages nine hours. Experience has demonstrated that, to keep up frequent communication between such

distant stations, from 200 to 250 birds are needed for each line of flight. By pairing birds in one place and feeding them in another, what is known as "there and back flight" is obtained, and with this it is possible to keep up a continuous to and fro flight between two stations. At sea this finds its best application with light-ships and off-lying stations in communicating constantly with the shore where the distance is not over 50 miles. In October, 1883, a light-ship broke adrift from her moorings in heavy weather twenty-two miles from Tornung, off the mouth of the Eider. Four pigeons were liberated from the ship and brought the news in 58 minutes. The messages are usually carried in a section of goose quill, about 1¾ inches in length and hermetically sealed at the ends. Light wooden cases are also sometimes used. They are fastened securely to one of the underneath tail feathers. The birds are marked either on a light aluminum band around each leg, or by a stencil mark on the underneath side of the wing, or both. They are also sometimes spotted with certain dots of different colored paints on the back and wings. In the Austrian navy the only station is at Pola, where they have 120 pigeons. Several flights from ships down the Adriatic to the home loft have exceeded 250 miles. In Belgium the government has no regular lines of communication, but 600,000 birds are owned by private individuals or clubs for sporting purposes. France has some 100,000 pigeons. It is estimated that 25,000 pigeons would be required in war time for Paris and its outlying circle of forts. Switzerland and Austria are developing their systems. Berlin has two lofts of 500 pigeons each, and Ham, Metz and Strasburg each 1000 birds. In 1888, Germany had 52,240 birds available. Spain has 18 stations and Russia has numerous stations on her western frontier. Messenger service by pigeon is a most valuable method of distant signaling at sea, and should receive the development and encouragement which its great value merits.

By Balloon.—Under certain very peculiar circumstances balloon messenger service may be utilized for naval purposes, as, for instance, off a blockaded port, with a favorable wind to make a free ascent and descent either from shore to seaward, trusting to being picked up by friends, or from seaward to shore to communicate with friends in the blockaded port. The use of a sea anchor in making a descent, and drifting at sea till picked up, makes one phase of this hazardous service at least practicable under some circumstances.

Going from seaward to shore is not nearly so hazardous, and under some circumstances might be of great importance. Pigeon service would, in this case, serve most purposes. The general subject of ballooning, as applicable to naval signaling, is considered under the head of Visual Signaling, where captive balloons are utilized. This form is both feasible and valuable, and is described in detail. Of the recent French manœuvres (1892) in the Mediterranean, the *Army and Navy Gazette* of August 20th says:

"A chief purpose of these manœuvres was to test the working of the semaphore and carrier pigeon service, as well as the captive balloon. The semaphore stations proved their efficiency, and Admiral Brissonby, in command at Toulon, was kept *au courant* with the progress of affairs, and was able to direct the whole of the defence (against the supposed attack on that harbor). Doubtless these stations and their telegraphic apparatus would be the object of an early attack in case of war. The despatches carried by pigeons reached the commander irregularly, some being promptly brought while others were long delayed. As to the balloon, it burst and was useless." (This refers to a captive balloon.)

II.—Day and Night Squadron and Distant Visual Signaling.

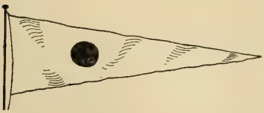
Day Visual Signaling.—Day visual signals are, as to character, either permanent or transient. Bad weather limits the application and range of either form. Fog, mist, or snow destroys their usefulness for the time being, and phonetic signaling must then come into play. The elements of visual signaling are form, color, duration, position and motion. With flags we have both form and color; with shapes we have form only, although color may come into play at short ranges; with the semaphore we have position; with the wig-wag we have elements of motion, and with the heliograph we have elements of duration. Heliographing is not here regarded as a method of naval day visual signaling, as its application is strictly limited to use on shore. In messenger service we have seen that the same general means exist afloat as on shore, although more restricted at sea both as to range and rapidity of communication. As regards telegraphy there is no limitation as to distance, and the speed and capacity of signaling have been in recent years most marvelously developed, but from a naval standpoint the telegraph wire and cable are only indirect means of occasional communication from one base on shore to

another. As previously stated, the development afloat has been in the direction of all around visibility. This points to the use of shapes for general squadron signaling. Mechanical difficulties are largely a drawback to the development of this method. Experiment is necessary and should be entered into seriously in our service. It promises much in the simplification of the code, as with the use of shapes the same code as used in the wig-wag and Ardois could also be used.

Flags.—Flags possess the great advantage that in one hoist three or four elements can be displayed at once, and for general signal purposes thousands of permutations and combinations can be made. The objections to the use of flags are that in a calm they hang limp; in an unfavorable breeze they fly on; in haze and smoke the colors cannot be distinguished; the colors get dull and soiled through the effects of smoke, powder gases, sunlight and rain; and in action the halliards are so liable to get shot away. The greater the number of flags in a hoist the greater the chance of making a mistake in reading the signal; also the longer it takes to bend on and hoist a signal. Using 10 flags and no repeaters, the chance of mistake in a one-flag hoist to the chance of mistake in a two-flag hoist is as 10 is to 10 x 9, or using 20 flags and no repeaters as 20 is to 20 x 19. The simpler or fewer the colors in a flag the less liability to make a mistake in reading, particularly if the breeze is light. The smaller the flags the quicker they can be handled, but the more limited the range of visibility. Mechanical devices and practice increase the rapidity of flag signaling. Snatching the halliards and running away with them on deck; devices for bending on and detaching quickly; putting lead weights on to bring them down quickly; all these add to smart signaling. Using different shaped flags to indicate the character of the signal from the shape of the uppermost and the number in the hoist, leads to quick reading. Experience has demonstrated that the buntings which possess greatest visibility are of the colors *red, canary yellow, black, white and blue.* Much, however, depends upon the way they are combined, upon the character of the light, and upon the colors not fading easily. As between white and canary yellow, the former soils easily, and on the fly end of a flag lacks visibility. Red with blue is also a successful combination. White is a good intermediate color with red or blue in horizontal or vertical stripes, or in a square patch on a red or blue field, but it is

poor as the fly or hoist of a flag or as a single color. Bunting should be rigidly tested in respect to fastness of color and non-liability to fade. No more than two colors should be used in any one flag, as the chances are increased of mistakes where the flag droops and only a patch of color shows. The five colors red, white, blue, black and yellow give a wide range of two-colored flags and pennants.

1. International Flags. By international agreement eighteen flags, representing eighteen consonants of the alphabet, are used in hoists of two, three or four flags to communicate at sea between ships, or between ships and shore stations, using a code book in which the meaning of each hoist is given. The total number of permutations possible, using more than one flag and not more than four, in which no flag appears more than once, is 78,642. Two flag signals having the letter B uppermost are attention signals; with a pennant uppermost, compass signals; and with a square flag uppermost, urgent signals. The three flag hoists are universal and express latitude, longitude, time, weights, numerals, and all ordinary sea signals. Four flag hoists, having the B flag uppermost, are geographical signals; with the pennant uppermost, are spelling and vocabulary signals and names of men-of-war; and with the square flag uppermost, they are the names of merchant vessels. Of these combinations, 1440, from G Q B C to G W V T, are allowed for distinguishing signals for men-of-war, and 53,040, from H B C D to W V T S, are for merchant ships. The assignment of these combinations to the names of ships is left to the government of each nation within the limits prescribed. The French Government has recently proposed to the United States and Great Britain certain changes, which are numerous in detail as to the additional signals required, and also as to the modifications and corrections of signals now in use; for instance, to give each flag a special significance, as F, "end of word," K, "repeat," G, "do not understand," etc., etc. The

X 

Z 

main proposition, however, is to add two letters, X and Z, which are to be represented by two yellow and black pennants. This

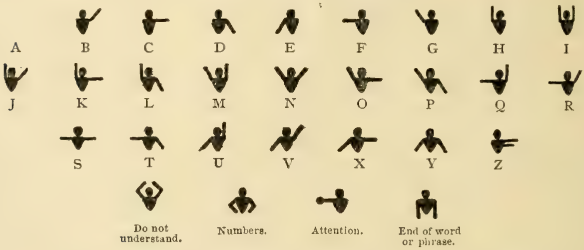
would increase the permutations from 78,642 to 123,500. In the main, the suggestions are in the direction of widening the scope of the code and increasing its efficiency. The increased speed of vessels and the rate at which they now pass one another at sea render quick signaling imperative, and the French are more keenly alive in these matters than any other nation. The British Government has submitted to France and to the United States a proposition to consider the extension of the international code to night signals and to adopt a phonetic code for certain purposes in foggy weather. No action has as yet been taken. In the Italian navy the international flags have been adopted for general signaling. The advantage to be derived from this is that using two and three flag hoists a total of 5,202 permutations are possible, which answers for all ordinary signaling; using four flags will add 73,440. Special code books are used, and only a few special and additional flags are needed for distinctive and code purposes. In the International Code no signal has ever more than one significance. The character of the upper flag and the number of flags determine its character on sight. Admiral Gherardi has submitted to the Navy Department a most excellent scheme for using alphabetical flags. As the international possess most of the virtues as to colors, etc., it would seem advisable to follow the example of Italy. It would simplify the study of signaling, and there is no advantage in making it difficult.

2. Naval Flags. Each nation has its code of flags which, when hoisted, convey special meanings interpreted in books specially devised and intended to be kept secret. As far as the secrecy of the alphabetical or numerical significance of each flag goes, it is of little importance. The key to the meaning is the important thing. The usual basis of the flag codes are the ten numerals, each represented by a special flag. Using 1st, 2d and 3d repeaters, the permutations and combinations using ten numerals and limiting the hoist to four flags gives 11,110. The English use a fourth repeater or substitute, which gives a five-flag hoist. They use altogether 58 different flags. The French have the most elaborate system of flag signals in the world. They have four sets of numerals. The first series are square flags, the second are "trapeze" shape, and the third are pennants. Separately each flag has a special meaning. The fourth is a telegraph series with nine square flags and five pennants. They can tell the character of signal by the upper

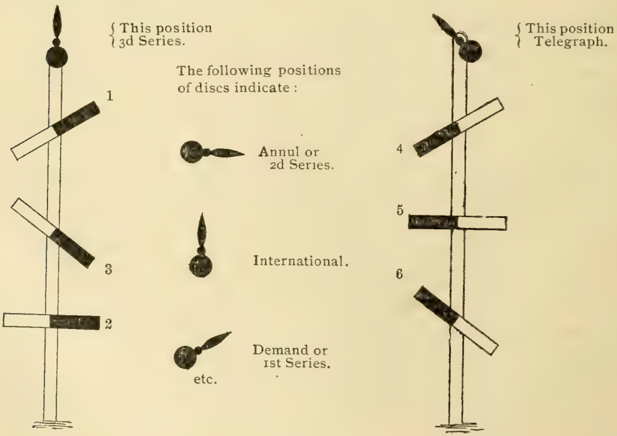
flag. The total is 51 numeral flags. Their flag signaling is so complicated that there is an official movement on foot to abolish their use altogether and substitute shapes. In our navy our signal books are very antiquated and few signals have been added. We have nothing on torpedo-boats and little or nothing on any modern appliances adapted to new ships. The modern demand is for one, two and three flag-hoists. We can certainly get in the numbers from 1 to 999 all the important signals. In any revision of the signal book, now so urgently demanded, the index columns should be arranged for either numerals or consonants (that is for both). In case shapes supersede flags they will probably be on the basis of numerals, although not necessarily.

The Semaphore.—Many officers in our navy, struck by the efficiency of this method of signaling as used aboard British vessels-of-war, have suggested its adoption in our service. Its supreme virtue is rapidity of signaling. Each character is made by practically one motion of one or more arms, which assume a definite position at which they are read. It is a three element code, it has forty-four characters, and it duplicates, with its ten numerals, ten letters of the alphabet. It possesses the same defect as the wig-wag, that it can be read only from one direction. An attempt has been made in the British navy to use the semaphore for night signaling. To this end the arms have been illuminated by reflected light or by lights on the arms. On the Nile and Trafalgar, and also on the Chilian armored cruiser Captain Pratt, light steel semaphore arms (perforated for lightness) have been fitted at the mast-head for signal purposes. There are two sets, the upper one for abeam and the lower for ahead. They are worked by endless chains running up the hollow steel mast operated from the berth deck. This is the development of the semaphore in the direction of increased visibility, both in increased size of arms and in the altitude at which mounted, and represents really the semaphore for distant signaling. It is not regarded as a pronounced success. One reason is that the lost motion in the endless chains leads to wrong positions of the arms. For day signaling the arms are painted black. Where the semaphore has been used at night, the arms have been painted white so as to reflect the light thrown on them. The defects of the semaphore are that it is a complicated code, hard to learn and to remember, that it is only adapted to day signaling, that it is

only visible in one direction, and that it cannot be used as a code for any other than the one purpose. In other words, it lacks simplicity and is limited in its range of usefulness. In the British navy, with its highly trained and well organized signal corps aboard each ship, and in the French navy, with the sea-coast defenses entirely in the hands of the navy, the question of simplicity is not so important as with us, where we expect so much from our combatant force. The code used has been explained. Using small hand-flags the code is transmitted as to method as follows, which is, however, the French semaphore code. Using the hands:



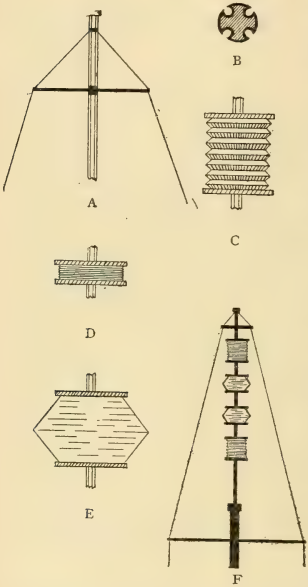
The French mechanical semaphore uses the same code as is used with the flag signals. It is manipulated as follows:



Wig-wag.—The elements are those of motion; the display of elements is successive and transient, and the method is slow. It possesses the defect that it is only visible in one direction. It is a most excellent method for our purposes because it can also be used at night by means of a torch; its elements are simple, it is easily learned, and with some such code as the Myer, it is adapted to all purposes of signaling. The code calls are initials such as T. D. U., G. L. U., etc.; the annulling, affirmative, repeat, error, etc., are special characters, and all other significations are spelled out. It is slow, but it is very simple, and we would make a great mistake to give it up for a semaphore code. In the German navy, using the Continental Morse, a dot is made by holding one flag out, a dash by holding two flags (one in each hand), and a front by crossing both flags over the head.

Shapes.—In squadron day visual signaling the use of shapes is only a matter of experiment. No navy has finally adopted them. The French are conducting some experiments, but the only information given out is that collapsible shapes are used, and that these are mounted on three arms projecting in the same plane from a common pivot. They are turned towards the observer just as the semaphore is. This destroys or neutralizes all the advantages of such a scheme, because, if we use for shapes figures of revolution, then from every point of the horizon each shape looks the same, and if we mount them on arms and confine their visibility to any particular direction, we destroy the one great advantage shapes possess over flags. If we turn them so as to display them successively to all points of the horizon, then we get visibility, but at the expense of speed of signaling. Unquestionably, the development of signaling by means of shapes is not along the lines practiced by the French. Collapsible shapes should open by one motion and close by reversing it. They may be made of canvas fitted to steel or wooden frames, and the collapsing motion may be made by a spring. The two most satisfactory shapes, from a mechanical standpoint, are cylinders and cones. If only one shape is displayed at a time the elements are made successively and the method is too slow for squadron purposes. The writer holds that the Myer code, using with it the four element numeral code proposed, is the ideal naval signal code, adaptable to all modern conditions. Also that the code is of the first importance, and that the means of transmitting

it somewhat secondary. To transmit this code by shapes we must have one shape to represent a 1, and another to represent a 2. To display all the elements of any character at one time we must be able to exhibit four shapes in one hoist or one display. The writer has unofficially submitted to Commander Sigsbee, U. S. Navy, whose inventive talent is so well known, a device for displaying shapes to conform to the Myer code, and it is his opinion that with several important modifications the scheme of shapes is feasible and practical mechanically. The device as modified by his valuable suggestions consists roughly of the following parts:

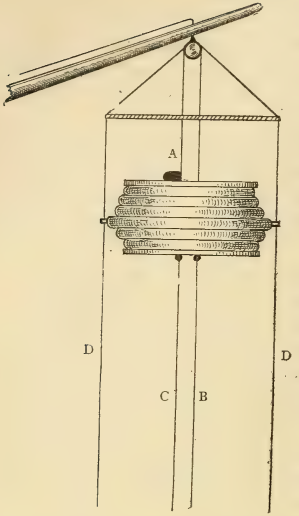


1. A signal mast of steel or wood with four grooves running its entire length, of which the positions are shown in *B*, which represents a section of the mast. This mast to be at least forty feet long, fitted with ordinary stays and backstays and with shrouds spread out or sprung out near the masthead to give clearance for making shapes on the mast.

2. Four shapes consisting of two light steel circular discs joined by a circular diaphragm of rubber, similar in general construction to a Japanese folding paper lantern. The lower disc is fixed to the mast, and the upper one can be raised by means of a cord which runs up a groove in the mast and over a sheave in the truck. When this is done the figure presented is that of a cylinder, as in *C*. When collapsed it takes the shape shown in *D*. Traveling on the mast is a loose collar inside of each shape fitted with steel ribs, somewhat like those in an umbrella. When the collar is held and the shape expanded, the umbrella frame opens out and gives the shape the appearance shown in Fig. *E*. The cords or wires which operate the display

and collapse of the figures travel in the grooves in the mast, and are worked by levers either in the tops or on a signal platform, or from deck. [It would be practicable, as in the English semaphore apparatus, to run the halliards and other signal gear inside a hollow steel mast and work the shapes from the berth deck.] Calling Fig. *C* a 1 of the Myer code, and Fig. *E* a 2, such a display as Fig. *F* would read 1221, that is, the letter M or the numeral 9 of the modified code. The discs might be made from 2½ to 3½ feet in diameter, and the shapes given a hoist of from 4½ to 6 feet. They would be easily visible from four to five miles from any direction of the compass.

If the shape representing 2 should be found by experiment to offer mechanical difficulties in operating the umbrella-like frame, we might substitute for it a collapsing ball, which would ordinarily house around the mast, inside of the space covered by the shape 1 when it is hoisted. This ball, when collapsed, would consist of a closely packed bundle of flat steel ribs surrounding the mast. When the upper collar is forced down towards the lower one, the steel ribs would take the form of a globe, which would represent a 2 of the Myer code, or a dash of the Continental Morse. The greatest difficulty in working shapes is experienced in blowy weather. The effect of the wind is to bind the steel discs, in the shapes proposed, to the mast, and prevent their being hoisted or collapsed. The effect of the mast is to steady and guide the shapes, and the form proposed would seem to offer less objection in bad weather than any other. British vessels-of-war are fitted with collapsing drums, which are rigged some 20 feet or more above the deck to a gaff of some kind, and are opened and collapsed on the dot and dash principle of the Morse code. They are barrel-shaped and, when expanded, the dimensions are as follows: height, 4 feet; greatest diameter, 3 feet 6 inches; diameter of heads, 2 feet 8 inches. They are rigged as shown in sketch. The drum is steadied by the guys *D*, and raised and collapsed by the ropes *C*. and *B*. *A* is a weight of 10 pounds to collapse the upper half by gravity. As shown in the sketch the drum is only partly collapsed. When completely so the thickness is only 8 inches. This is a device for fleet signaling at as great a distance as has yet been found practicable in the British navy. During the manœuvres recently, these drums were found to be much too small. The subject will be discussed further under the head of "Distant Day Visual Signaling." It is a very slow method



of signaling, but it represents one step in the direction of the use of shapes, and is a further movement on the part of the British navy away from the semaphore for anything like distant signaling. If used for distant signaling, powerful tesescopes are needed, and the height above deck must be increased.

The shapes proposed by the writer, operated on a mast specially constructed for the purpose and of sufficient size to be visible five miles, would seem theoretically to possess the following advantages: 1. Visibility from every point of the compass; 2. Ability to transmit an alphabet or numeral code; 3. Simplicity and uniformity in that the same code can be used for this as for all other purposes. If flags are to go, some such system must take their place.

Distant Day Visual Signaling.

Distance destroys the value of color and increases that of form. In our navy our largest numeral signal flags are eleven feet long. At a distance of between four and five miles, under the most favorable circumstances, with strong glasses, the limit of visibility as to color is reached. The shapes of the flags can be made out at five miles or more. The development of methods of distant signaling must, therefore, be in the direction of shapes of some kind. The dip of the horizon, of course, limits observation, so that any method must fail at a certain distance. Before discussing the question of apparatus, it may be well to outline briefly some experiments made abroad in naval ballooning for signal purposes. A captive balloon carrying a signalman gives, of course, an increased range of visibility for observation and signaling.

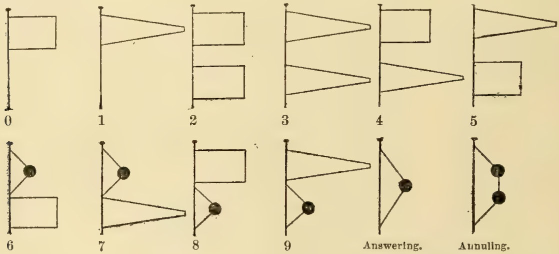
First, as to some recent experiments: On Sept. 6th, 1890, the torpedo-boat L'Audacieux, with a captive balloon, attached by a short cable, steamed from Toulon harbor to Hyères roads, a distance of twenty-one miles, in two hours. The balloon was transferred to the St. Louis, the gunnery ship, and the captain ascended and gave orders to his ship by telephone at a height of 250 meters. Lieutenant Serpette ascended, cast off the cable, and made a free ascent of 1800 meters. He came down in the open sea, and by means of a sea anchor, hereafter described, he waited till he was picked up by a torpedo-boat, which towed the balloon in. Afterwards the balloon was taken on board the Formidable, and was filled behind the armored turret on the after deck, hauled to the mizzen-top, and several officers successfully made a captive ascent. They ascertained that in clear weather all the details of the coast from Marseilles to the extreme point of the island of Hyères were plainly visible, and that no building or ship for 30 or 40 kilometers around could escape the notice of an observer in a balloon. The bottom of the sea to a depth of 25 meters was clearly distinguishable, and the movements of a shark were watched with interest. On the high seas no special value may be assigned for balloon service for reconnoissance, but for the operations of a fleet near a coast, in attack or defence, it may be made to play an important part. From a signal standpoint an observer in a balloon could telephone to the deck any signals or movements displayed ashore, or could, by signal flags, or the wig-wag, communicate with other vessels of the fleet at distances much greater than could the ship itself.

For night signaling, as hereafter described, the balloon offers several valuable methods. Balloons for French naval purposes are made of Pongee silk, with several coats of varnish. They are spherical in form, and have a cubical contents of about 320 cubic meters, with a diameter of 8.5 meters. They carry a wicker basket and a steel cable with a telephone wire in the heart. [English military balloons have cables ¾ in. in circumference; breaking strain, 1 ton; weight, 10 oz. per foot. The English telephone is a patent and does not require a battery.] They are filled with hydrogen gas, which is stowed in steel cylinders holding four cubic meters of hydrogen, under a pressure of 120 atmospheres. A tube filled weighs 30 kilogrammes. [English military balloons, hydrogen tubes, 70 lbs., 120 cwt. gas.] The sea anchor consists of a large water-tight bag, stiffened

above and kept open by an iron hoop to which the anchor line is attached by means of a linen band. In the bottom of the bag is a valve which can be opened from the car of the balloon by means of a cord. The balloon is usually anchored with 40 or 50 meters of line. The weight of the water in the bag prevents the balloon rising, and keeps it captive unless the valve is opened to free it. Ballooning, except by experienced observers, offers little for an immense outlay of money, time and storage space. Wind is the great enemy of the balloon, and sea-sickness, escaping gas, excitement and inexperience are apt to neutralize most efforts, unless a good deal of practice is had in time of peace. Accidents are not infrequent, and the expense is great, but at critical times they fill an important place.

Distant Day Visual Signaling.

The French use, as their distant code, large flags and a black ball or shape. Form of flag and not color is what counts. The code is as follows:

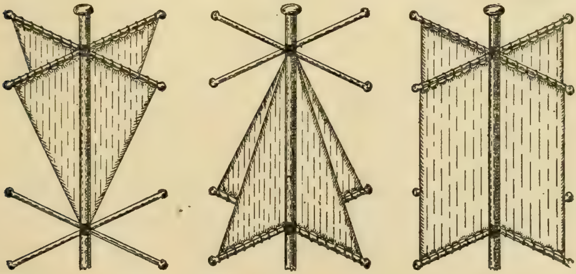


(The code calls are hoists of three elements).

French ships, in communicating with distant semaphore stations, use a cone in place of a ball. In communicating with one another they use the ball, but *can* use the semaphore code.

The International code of distant signals is as follows: There are three symbols, (1) a ball, (2) square or rectangular flag, and (3) a triangular pennant. The alphabetical characters have each three symbols. For instance, B. With the coast semaphore, used by all nations by international agreement, an arm pointing downward represents a pennant; an arm horizontal, a ball; and an arm upwards, a flag. The disc on top at horizontal is the answering signal, and the disc vertical indicates that distant signals of the International code are being used.

In the British squadron manœuvres of 1891 the collapsing drum issued for service, as described, was found too small for distant day visual signaling. Aboard different ships different devices were tried. On some vessels this drum was used in conjunction with large national flags folded as pennants or as narrow flags, some 22 feet long and about 4 feet broad. With these some prearranged code was used. The difficulty was that the flags did not show except in certain directions, being thick and only held out in a stiff breeze, and then were only visible in certain positions. On other vessels immense collapsing drums were built of timbers and canvas, which required the entire watch on deck to hoist and collapse, using the Morse code. The general drift of all the experimenting was that it is impossible to communicate accurately or with any satisfaction at greater distances than those at which shapes of about 6 feet in height are plainly visible. In other words, shapes larger than 6 feet are too difficult to work and collapse in any kind of a breeze. The question is yet in an experimental stage. It has been proposed that sails be used—for instance, as in Figs. *A*, *B*, and *C*—to transmit the Myer or Continental Morse code. Fig. *A*, with the heads hauled



A B C

out, would, for instance, represent a 1 or a dot; Fig. *B* a 2 or a dash; and Fig. *C* a 3 or a "front." Of course the sketch is only a rough outline, and such a scheme appears fanciful and unseamanlike. Consider, however, with a fleet undertaking actual operations, how necessary it must be at times to communicate with the scouts or with vessels at a distance. Some means must be devised. However much we may respect the traditions of the service, we all know that most of the spars in such ships as the Chicago and

Newark would go ashore in time of war. In ships which are now building we ought to design the spars with due regard to this vital question of signaling—not, of course, to rig such an apparatus as shown in Figs. *A*, *B* and *C*, which would simply be used in an emergency and rigged with the resources on board, but to seriously get rid of top hamper, to consider questions of all-around visibility of signals, and to consult the demands of modern conditions in general. As has been said, the question of distant day signaling is in the experimental stage. Nothing satisfactory has emerged from it all. The chief defect which is likely to develop itself in some such system of shapes as proposed by the writer is that it will probably be found that refraction will distort the shapes at long distances and render distinction between them a matter of considerable uncertainty. Any such defect is, of course, fatal to distant signaling. Experiment can alone settle these points.

Night Visual Signaling.

The utilization of the electric light has added vastly to the rapidity and range of night signaling for squadron purposes. Night increases the value of color as an element in signaling, and destroys that of form. With powerful lights and with increased altitude to overcome the effects of the dip of the horizon, the range of night signaling may be made to far exceed that of distant day signaling.

Wig-wag.—Night signaling with the wig-wag code by means of a torch finds now only a limited application, and that for special purposes, as the introduction of some such system as the Ardois has practically superseded it, owing to the advantage the latter offers in rapidity and accuracy of signaling. With the electric apparatus all the elements of a letter or character are made in one display, and, being answered by the same display by the receiver, mistakes in receiving are eliminated. In the army several improved types of torches for night wig-wag have come into use, and have also been adopted in the navy. With the electric light, however, an incandescent lamp on a staff offers considerable advantages over the torch, especially in windy weather. In transmitting the wig-wag by night, a lantern is placed at the feet of the sender to mark his position.

Semaphore.—Experiments have been made in the British navy, as previously stated, with several devices for lighting up the sema-

phore arms. One plan has been to paint the arms white and throw on them a reflected light from a group of incandescent lamps. A semaphore for night work has also been tested, in which the arms carry a number of incandescent lamps to outline their positions. Neither plan is regarded as entirely successful, and the winker light is generally relied on for night squadron signaling.

Winker or Flash Lights.—In both the British and Italian navies electric lamps are used with some device or shutter to flash dots and dashes, using the Continental Morse code. To get increased range of signaling, lamps of fifty and a hundred candle-power have been experimented with. The great defect has been found to be that with such high-powered lamps the carbon does not flash or die down quickly enough. This consumes time, as the dots and dashes have to be made much longer than in telegraphy, but the Italians have overcome the difficulty somewhat by using a globe lantern in which a nest or group of six or eight 12 or 16 c. p. lamps are used, all worked with one key in the same circuit. These are mounted on the trucks of torpedo-boats and very high on other vessels. The smaller carbon filaments are found to work successfully, and the fixing of the lamps rigidly on the trucks of smaller vessels has been found to be a great advanage in a sea way. In the British service one device to overcome the question of the slowness of the carbon has been to have a multifiber filament, that is to say, one made up of a bundle of smaller ones. This has reduced the defect very considerably. Another device has been to keep the lamp burning and operate shades to obscure the light. On some vessels this shade is simply a bag fitting over the lamp, operated by halliards on deck, which are attached to a lever which is worked up and down. A very successful device, invented by Captain Scott, R. N., has been tried but not adopted. It consists of a high-powered lamp, surrounded by a number of vertical shutters worked by an electro-magnet and a spring. The shutters revolve through 90° when a current is sent through the electro-magnets by the signal key, and the light is exposed all around until the current is broken, when a spring snaps the shutters to and obscures the light. The lamp has a resistance in it which is thrown in when the shutters are in an obscuring position, so that the lamp does not burn at full power. This saves wear on the filament. In our navy no regular device of this kind has been adopted, although some experimenting was done on the

Trenton and since carried on in the newer ships. As long as we have the American Morse as the service code, no serious attempt is likely to be made to perfect one. The Ardois or some such system is so much more rapid and certain than winker lights that the latter can only have a limited application. In a series of experiments off Montevideo in March, 1892, it is recorded that a 32 c. p. white light, at the main truck of the Bennington, was visible on a clear night over eight nautical miles, which shows the value of a truck lantern for distant wig-wag, where the lower lights of the Ardois would be hull down.

Coston Signals.—In the absence of any better system the Coston lights were at one time widely used for naval and commercial purposes. Recently an improved percussion arrangement was added to these signals, and the Navy Department was prevailed upon to order a test. In March, 1892, a board was appointed on the South Atlantic station to make a series of trials of the Coston, Ardois and Very systems on board the Chicago and Bennington. The night selected was a dark, star-light one, with atmosphere unusually clear and free from haze or mist near the horizon. Of 50 Coston lights burned, at distances varying from three to eight miles, and at a mean height of 32½ feet on each ship above the water, 29 were correctly read, 20 incorrectly read, and 1 was not seen. Eight miles was the limit at which the dip began to interfere seriously. Nine signals were marked doubtful on account of the confusion of white and green, as the shade of difference was very slight. A blue light was read as green. The signals averaged 30 seconds in burning each color of which it was composed. The finding of the board was that "The Improved Coston Night Signals are entirely unsuited for naval use. Forty-two per cent. of them failed to be correctly read, the color distinction being very poor. This is a cardinal defect, and would alone be sufficient to cause the rejection of a signal for military purposes; but in addition thereto the Coston signals show the following minor objections:

1. They require a long time to burn, and signaling with them would be much slower than with the Very signals.

2. They make much dirt, the products of combustion flying about the deck and defacing paint work.

3. They make a blinding glare, rendering it impossible for those standing about to see anything inside or outside of the ship.

4. They are made only by the manufacturers from whom renewed supplies must be ordered, and cannot, like the Very's, be reloaded on board ship.''

Electric Night Signaling Apparatus.—An experimental apparatus and night code was used in the North Atlantic squadron in the summer of 1890 and until the latter part of 1891, the invention of Lieut. H. McL. P. Huse, U. S. Navy. It was intended for night signals with colored lights, and day signals with collapsing shapes; for red light using a cone, and for green light a cylinder. The following is the description as issued for trial:

In this system, one red and one green light are necessary. They must be placed sufficiently far apart that each may be distinctly visible.

The Very code for night signals may be used in connection with any of the signal books, or a message may be spelled out by the American Morse code.

The *general call* is made by exposing a green light until it is answered by all the vessels within signaling distance.

The *special call* is made by signaling the initial letter of the vessel called until answered.

The answer to a call, or I understand, is made by showing a red light.

The repeat, or, I do not understand, is made by showing a green light.

NOTE—This change is made to preclude any mistake as to what vessel is making the call. If the answering were green, attention might be directed to an answering vessel instead of to the calling vessel.

Attention may be drawn by firing a red Very signal.

The lights will be made in succession, according to the Very code accompanying this circular.

Use telegraphic book: Show both lights together twice, followed by the designator G G R G.

NOTE.—Lights should be exposed about two seconds and be separated by an interval of about two seconds. It is not intended that measured time elements shall enter. Times of exposure and of darkness are given simply as a guide. A little practice will enable a signalman to make his lights and intervals regular; this is all that is necessary.

Signals are separated by the designator.

The completion of a signal is indicated by making two designators.

Use General Signal Book, make three doubles, $\left.\begin{matrix}R\\G\end{matrix}\right\} \left.\begin{matrix}R\\G\end{matrix}\right\} \left.\begin{matrix}R\\G\end{matrix}\right\}$.

Use Morse code. Expose the red continuously; while green is shown intermittently twice; then proceed with the message, a dash being green and a dot red. Words are separated by a double.

Two dots separated by a space are made thus: the red is exposed continuously for about six seconds; during the third and fourth seconds, the green is also exposed.

"Error, I have made." With any code, expose the green continuously while the red is shown intermittently three times. If using the Very code, begin again with the designator preceding the error. If using the Morse code, begin with the last word correctly sent.

To break, show a green.

To start after breaking, show a red.

Instead of the red and green lights, any other recognized means may be used in answering, as a torch, or two lanterns, or Very signals. In using Very signals for this purpose, the signals fired must conform in color with the lights called for.

The objections to this system are that it uses a green transmitted light, it is very slow, and with such apparatus as the Sellner, Ardois, or Kasolowski, it compares most unfavorably both in rapidity and certainty of signaling.

A brief discussion of the theoretical requirements of an electrical night signal apparatus will throw much light upon the lines along which these modern systems have been developed. In the first place, *as to colors*: Three have been more or less used, green, red and white. Green has now been entirely discarded. As a transmitted light it lacks visibility and is confused with white. Red and white have come into general use, but in the most recent apparatus a pulsating white light has been substituted for the red. In a French experimental apparatus, as previously stated, both red and white pulsating lights have been introduced. In the face of the exhaustive experiments abroad we are compelled to accept the dictum that a white light is visible further than a red (which also conforms to theory) and that a pulsating white light is visible further than a fixed white. *As to types of lanterns used:* The range of visibility of a light at sea in clear weather depends upon the height of the lamp above the water, its candle power, and the character of the lense or *reflector* used. Some apparatus limit the visibility to a certain direction by putting in shades and reflectors. The requirements of a lantern are as follows:

1. It should be double, and provided with a diaphragm to exclude the light of one lamp from the other half of the lantern.

2. But one lamp in each lantern should be displayed.

3. The lantern should be air-tight to exclude moisture and powder gases which erode the terminals and contacts.

4. It should be fitted with a Fresnel lense, which concentrates the rays in a horizontal plane.

5. It should give visibility all around the horizon.

6. It should be so suspended as to always take a vertical position in order that the rays of light may be thrown out horizontally, but not so freely as to strain the leading wires or chafe the main cable.

7. It should be simple in construction and easily opened to replace a lamp burnt out.

As to candle power of the lamps: We generally use 32 c. p., which gives excellent results. The French use 30 c. p., and the Italians 25 c. p. High power, of course, gives increased visibility and distinctness. *As to cable:* In the wiring of signal lamps the leads are generally made up into a cable and protected from chafe by a covering. A common return is generally used and separate leads to each lamp. In connecting with the signal box or key-board the attachment should be made by a coupling and not by separate wires to separate binding posts. The coupling facilitates testing out the circuits. The cable should be more or less permanently suspended from a yard-arm or working gaff, and secured at intervals to a taut guy or backstay to take its weight. In the Italian navy the cable is sometimes suspended to the fore and aft horizontal stay between the military mastheads. There should be a switch in the common return, working automatically, so that the current will not be thrown on till after the contacts are made for signaling. This prevents sparking, and consequently burring and wearing of contacts in the signal box. *As to signal box or key board:* Contacts which are made against the face of a spring are not reliable, as the springs weaken in service. The box should be water-tight, and the movement of the key arm should be as simple as possible to give speed in signaling. Boxes are sometimes set at an angle to facilitate operating the lever or arm. The face of the disc should be marked opposite each sector as to the display of lights and the significance thereof. *As to the number of lights* in the permanent hoist: The French at one time with the De Meritens apparatus, used eleven. The two upper and the two lower lights were red, and the intermediate were white. On account of the blending of the lights, owing to their close spacing, the range of visibility was very limited. This system was superseded by one of four single lamps. Experiments are now being conducted with four double lanterns. The Italians and Austrians have adopted four; Spain is experimenting with four; and Germany has adopted

three (all double lanterns). The British Government has ordered a three-lamp apparatus for experiment, but the system meets with but little favor. We have practically adopted a five double-lantern hoist, in that we have committed ourselves by contract in the ships now building to the use of the Ardois or some similar apparatus. The question involved is this: The board organized on the South Atlantic Station to test the Ardois and other systems report that "Under ordinary circumstances the Ardois signals can be read with certainty at a distance of four miles. By actual experiment the Ardois signals of the Chicago were read from the Bennington five miles distant with night glasses, the lights being distinct both as to number and color:" But the Chicago lights are 32 c. p., spaced 5 meters, or 16 feet 5 inches, apart, and the lower lantern is not less than 35 feet above the water line. We fail, however, to realize that our more recent ships have no such spars, and that a modern squadron is made up of all sorts and conditions of craft. The auxiliary vessels of a fleet, the despatch vessels, the torpedo gunboats, the torpedo-boats and repair vessels, the swift commerce destroyers, and also the low free-board battle-ships offer no such hoist for signal lanterns as will allow the upper lantern a height of 100 feet above the water line. If our service code requires it, and if we want five lanterns, we must, of course, spar all our vessels with some regard to the requirements of space between lanterns. With five lanterns, the scouts of a fleet, the vessels on which devolve the reconnaisance, and on which depend the rapid and accurate transmission of important intelligence to the main body, will be just the ones whose hoist of lights would be most limited in space and hence in visibility. With four lanterns instead of five, the maximum distance would be greatly increased.

Devices Used Abroad for Night Signaling.

Berg's.—This has been experimented with in the German navy. It consists of three oil or electric lanterns with a white shade fixed in front of them, and with a movable red and a movable green shade so operated by electro-magnets as to throw at will a white, red, or green light. Where electric lights are used, a small hand dynamo gives the current. With this apparatus twenty-seven three-light signals can be made. The defects are that it lacks range; it

gives visibility only in one direction; and it uses the green transmitted light, which is limited in visibility and leads to confusion with the white.

Conz.—This apparatus is patented in England, the United States and Germany. It is a German invention. The last named government has ordered 100 sets for installation, which practically amounts to adopting the system. Three double lanterns are used with the colors red and white. The white light has an opal shade, but no device or lense is used for intensifying the power of the lamps. Resistances are used to keep the required current constant. Fourteen characters can be transmitted by this apparatus.

De Meritens.—This is used in the French navy. It has eleven lamps on a backstay, each lamp having a separate key. There is a tell-tale box to show what lights are on. The two upper and two lower lights are red, and the seven intermediate are white. This device lacks range, and is in a fair way to be superseded.

Ducretet.—This was used in the French navy. It consists of four single lanterns transmitting fifteen different signals, showing, however, only in one direction. It is out of date. The Sautter and Harle apparatus uses the same code as the Ducretet but is simpler in design, and has a switch in the circuit to prevent sparking.

French Experimental.—This is being tried in the French Mediterranean fleet. It consists of four double lanterns, half red and half white; it has eight separate leads and a common return; and it uses a pulsating or fixed current at will. The pulsations are given by a hand key. It uses a four-element code: (1) a fixed red, (2) a pulsating red, (3) a fixed white, and (4), a pulsating white. Each display has four lights. If less are shown, an error is evident and the signal is disregarded. This apparatus is quite up to date and gives a very flexible code.

Kasolowski.—This apparatus is used in the Italian navy. It has four double lamps of 25 c. p., and for torpedo-boats has a space of 5 feet between lanterns. Each lantern is double, the lamps being carried in a bronze frame which is held rigid between two guys which are slung from a gaff or yard-arm and set up taut on deck. For vessels not provided with an incandescent plant a hand dynamo operates the circuit.

Sellner.—This is unquestionably the simplest and most widely used night apparatus yet invented. In one form or another it is

found in both the Austrian and Italian navies, as it is practically the same as the Kasolowski, and similar to that used in the German navy. The latest model is, however, a great improvement on the older forms. One of these was purchased by our government and mounted on board the U. S. flagship Chicago in December, 1891, for trial in comparison with the Ardois. As it was fitted with four double lanterns, which is largely the custom abroad, instead of five, it was for convenience marked with the characters of the International code, using a few special and code calls. No lenses are used in this type in the lanterns, but instead plain red and ground white glass shades are fitted. With the apparatus sent two screens or blinds were attached to each lantern so as to make the display in certain directions, this being the custom in the Austrian navy. As these blinds can be easily and readily removed, they form no real part of the apparatus unless desired. They are simply prescribed by the Austrian naval authorities in their contracts. There is a device fitted to the transmitter or key box by which small resistance lamps may be thrown in or out of circuit to keep the current constant. These are intended for use with a hand-power dynamo, but can also be used with a regular dynamo as a tell-tale showing the signal displayed. The official report was made by Lieut. S. A. Staunton, U. S. Navy, as to the comparative merits of the Sellner and Ardois apparatus, and he objected to the Sellner as follows: 1st, to the marking of the instrument with the International code as not giving a fair test with the Ardois, which uses a full alphabet; 2d, to there not being thirty displays provided for, which is the maximum for four lights; 3d, to the use of the screens or blinds, as destroying the greatest value of the apparatus, viz., all around visibility; 4th, to the lanterns not being provided with lenses for strengthening the lights; 5th, to the awkward motion of the switch or lever on the transmitter for signaling; 6th, to the use of the resistance lamps as adding complications; 7th, to the cable not having a coupling for ready detachment for testing out the circuits; and 8th, that in point of general workmanship it is inferior to the Ardois. This represents, of course, an individual opinion. Against it must be set the fact that one of our best authorities in naval matters pronounces the Sellner apparatus the simplest and most endurable in service of all those in use in the various navies. It may not compare in workmanship, but it costs $700, delivered in this country, as compared

with \$1100 for the Ardois. The transmitter can easily be arranged for displaying thirty characters, and, using the Myer, Very, or similar code, can transmit an alphabet or numeral code without difficulty. Lieut. Sellner, of the Austrian navy, the inventor of the apparatus, replies to the remaining objections of Lieut. Staunton, as follows: The blinds form no necessary part of the apparatus. The signal switch or lever is purposely made of not too easy manipulation to assure the attention of the operator. After numerous trials the use of lenses with the lanterns was abandoned on the score that such arrangement failed to increase the range of the signal. This range depends upon the distance the lanterns are spread from the others in their hoist, and if this distance is 4 meters, the signals are well visible for about 5 miles. Where the intensity of the incandescent lamps reaches 32 candle power there is no use of increasing this intensity, since no longer range of the signal is thereby attained. The use of a coupling in the cable is objectionable as introducing a break in the conductor, and hence an element of unreliability. The principle of plug contacts in the transmitter is where this apparatus is superior to any other yet devised. In large ships there will always be two complete night signaling apparatus, thus avoiding difficulties arising from masking of lights, failure of lamps, etc. These arguments on the Sellner apparatus are here given in detail to show that this question is not to be settled off hand. The original Ardois apparatus has many faults, which in new designs in this country are being remedied. The field is an open one. The problem is merely to display certain combinations of lights. Experience abroad cannot be ignored. Where we are making a mistake in our navy is, on the one hand, in not fully recognizing the immense value of such apparatus, and on the other, binding ourselves to the use of five lanterns instead of four, and to the use of an extremely objectionable and unnecessary code.

Massari.—This is a new Italian apparatus on trial in the Italian navy, similar in some ways but simpler than the Kasolowski. The transmitter or key box has a hinged lever which lifts and sets down at the proper sector, making contact against the face of a spring, which is an objectionable feature. A Morse printing apparatus receives the signal made on slip of paper. The same types of lanterns and the same code is used as in the Kasolowski.

Ardois.—This apparatus has been adopted in our navy and, in

all, fourteen sets have been ordered from France. For the ships building at navy-yards the contracts are let in this country, and many improvements are being introduced by the contractors, and by suggestions from the office of Electric Lighting, Bureau of Equipment. The foreign type, as mounted first on the Chicago for trial, was described by the writer in No. 58, Proceedings Naval Institute, 1891. The new features are the lantern and key box or transmitter. The new lantern is air-tight and water-tight. A special feature is the readiness with which a burnt-out lamp may be replaced. Another feature is in the lead of the wires through the center of the top and bottom, enabling the lamp to be suspended at its middle point to swing freely and remain vertical, thus insuring the transmission of light in the horizontal plane. If a lantern with a Fresnel lense is canted, the light is not visible as far as if the lantern is vertical, and hence the rays of light horizontal. A further feature of the mount of the lanterns is the use of two parallel stays to which the lanterns are secured. The contacts in the key box are the same as in the old, but the box is water-tight. There are sixty-four sectors, but tbe marks radiate from the center, and the lever works around the circumference of the box. The pistons which make contact with the bosses or stops are beveled and rounded to give good contacts. It is, however, a grave mistake to use the so-called Ardois alphabet. It is inferior in every particular, save one, to the old Myer code. As to the folly of adopting five lanterns instead of four, it need only be pointed out that when we go on paying $1000 a piece for such apparatus for vessels like the Vesuvius that cannot mount five lanterns, and also for the short-masted new ships (even like the Philadelphia), and when we are committing ourselves indefinitely to the use of codes that violate every principle of signaling, one voice of protest is not enough to arouse the least official interest in the subject. When, however, at our own invitation, we assemble a fleet in our harbors next May, we will make an exhibition as to signals that will give us no reason to congratulate ourselves. The Ardois apparatus is an excellent one; but the field is an open one, and we want the best. There is, however, no excuse for the existence of the Ardois code, and there is no hope of the Myer code being re-adopted.

DISTANT NIGHT VISUAL SIGNALING.

As previously stated, night destroys the value of form and increases that of color. To increase the range of night signaling, we must overcome the dip of the horizon, and must increase the power of the lights used. All around visibility is a prime requisite, and the conformity of the code with that used in squadron cruising is very desirable.

By balloon.—Balloons give increased altitude, and hence increase the range of signaling. Mr. Eric Stuart's signaling balloon, tried recently at Fulham, England, is made of varnished cambric, and is therefore translucent. It is 18 ft. in diameter, has a capacity of 3200 cub. ft., and is controlled by a cable 500 ft. long, weighing 35½ pounds. The balloon contains six incandescent lamps, each of 10 candle-power, and the electricity is supplied from 26 accumulators by means of wires running up the cable. The signaling key has carbon contacts. England and Belgium have purchased for army purposes the Bruce Electric War Balloon, which is made of a translucent material, and is operated similarly to the above. At Heligoland, in 1891, a German squadron used, with great success, a captive balloon for distant and squadron night signaling. Incandescent lamps attached to the underneath side of the car were operated by a key using the Morse code. Arc lights were also used, and, besides lighting up the surrounding harbor and shore line, the beam was used for distant signaling.

Search lights.—The beam of search lights thrown on low, heavy banks of clouds offers a feasible and useful method of distant night signaling. With vessels hull down and practically below the horizon to each other, it is the only method possibly available. Search lights are fitted with shutters for this purpose, and such signaling occupies a definite place in any scheme of night signaling. In August, 1892, a search light used on Mt. Washington, N. H., transmitted a message which was read on the clouds overhead at Portland, Me., 85 miles distant. The beam was thrown upwards at an angle of 45°, and it has been estimated that to reach Portland it must have been 110 miles long, and was reflected from clouds 80 miles overhead in the last named city.

Very's signals.—Red and green stars are projected from a pistol to a height of 100 feet or more. This height is limited by the character of the stars, which cannot be made tough enough to stand the

increased velocity and pressure of larger charges. Exhaustive trials have been conducted under the supervision of Lieut. R. T. Mulligan, U. S. Navy, whose report has not yet been adopted as to the recommendations made. As to colors, all shade into either red or white at any distance, so that only two are practicable. Green was recommended and is used, but white is quite as good. All cartridges deteriorate in service. The original bracket code has not been formally abolished. Lieut. Mulligan's four-element code is issued experimentally, and is very successful. The firing pistol is still issued. It is inferior to the short double-barrelled shot guns recommended. The green star should be changed to a white. This is not particularly important, except for the sake of uniformity with the Ardois. It is not feasible to transmit the alphabet by the Very code, as it takes too many cartridges. In the experiments made by the board of officers in the South Atlantic, previously referred to, 13.7 nautical miles must be taken as the practical limit of the present Very outfits furnished ships. As eight miles is given as the limit of deck signals, the five and seven-tenths miles of further visibility must be due to the projected height of the stars. The official report of the board states that "The Very's signal meets all requirements for long distances. It is slow but certain, the color distinction being excellent; and with the lights grouped in fours to avoid bracketing, repetitions are seldom necessary. It is not suited for tactical signals because it is slow, and because it is not absolutely certain that the signal has been correctly read, and an error in tactical signals may produce collision. Certainty of correct transmission can only be assured in a night signal by repeating each display back to the sender. The scope of the Very is limited by the number of cartridges supplied. A long telegraphic signal would quickly exhaust the allowance. These cartridges can be reloaded on board ship, red and green stars being supplied for the purpose."

This excellent system of signals is capable of much improvement in detail. With brass reloading cartridge cases, excellent pistols or guns, and a four-element code, we would have the best distant night method in the world. The French use Coston signals, but supplement it by a code of lanterns hoisted in groups similar to flag signaling.

III.—Phonetic Signaling.

In a fog visual signals are, of course, useless. The only resort is to sound, using some phonetic code transmitted by drum, bell, gong, horn, bugle, whistle, siren, or gun-fire.

Squadron Phonetic Signaling.

Fog-whistle. — The steam whistles of vessels-of-war should be fitted with elbows in their pipes and drain-cocks for running off the condensed steam. Hand levers should be fitted to take the place of whistle cords. These should be capable of unshipping when not in use. Fog-whistle drills should be instituted in squadrons to perfect officers and men in the use of a code. Canvas screens should be put up around those on the bridge in charge, and at the wheel, and the conditions should be as nearly as possible those of a fog. Such drills are most important and valuable. At present in our navy we have no authorized method of transmitting our service code on the fog-whistle. As this American Morse code is dangerous to navigation, it is probably just as well that no method is prescribed. All vessels should be fitted with audiphones or other mechanical means of locating the direction of sounds in a fog. The importance of a squadron keeping in touch in foggy weather, and the danger thereof, unless an efficient phonetic code and apparatus are used, would seem to warrant some official interest in the matter. The French flash lantern and fog-whistle code is as follows :

1.	-	6.	—
2.	- -	7.	- —
3.	- - -	8.	— -
4.	- - - -	9.	- - —
5.	- - - - -	0.	— - -

Using a bell, gong or drum, a dot is one sound and a dash two successive sounds. The superiority of a four-element Myer code over this or any other dot dash numeral code is most apparent.

Distant Phonetic Signaling.

Rapid fire guns offer a good means of transmitting a code at a distance in a fog. It is best to limit the code to numerals, although with an interval character like 2 2 1 2 it is possible to transmit an alphabet. A numeral code would, with a telegraphic dictionary,

effect the same purpose. The French officially prescribe the above code for gun-fire purposes, using two successive fires for a dash.

Conclusion.

In discussing the various methods of signaling here presented, nothing has been said of the relation of signaling to tactics. We have discussed methods only, and have endeavored to simply show wherein and in what measure naval signaling differs from army signaling. Tactics demand of methods of communication three things: reliability, simplicity and rapidity.

Reliability involves mechanical perfection as to not failing at critical times, and certainty as to the message being received as sent. This is usually insured only by repeating back, which is, however, at the expense of rapidity.

Simplicity implies the use of a code of few elements covering a wide range of usefulness. The fewer the elements, the slower the signaling, but the greater the range of visibility, or the more reliable the signal as to distinctness.

Rapidity is, therefore, limited by the consideration of simplicity, and increased by mechanical perfection and reliability, which last restricts the too rapid methods of signaling. Tactics demand rapidity, but the crowning virtue is reliability.

Therefore, *that method is best which is most reliable and which is as simple and rapid as is consistent with absolute reliability.*

The question of interior communication on board ship affects tactics in the extent to which the whole ship is subordinated as a unit to the guiding mind which is working out the problem before it. The accurate signaling of the range, the constant touch necessary between the bridge and the engine room as to speed and keeping position, the net-work of communications to the torpedo tubes, batteries, ammunition supplies, water-tight subdivisions—all this is a problem in itself, but it is entirely a matter of methods and not of codes.

We must bear in mind that in our own service we are in a transition stage, so that any apparent criticism of methods is really only the application of experience to the modernizing of our methods. From a tactical standpoint the signal books need a general revision, and in view of the possible use and wide range of alphabetical characters (as in the international code), the index for entering the

books and each signal itself should be given both as a numeral and as a group of letters. As to the use of action or battle signals, there are many who hold that in a general action no signals can be read or will be heeded. Single flags are, however, advocated for battle signals, and these should have an alphabetical significance as in the international code. This would enable a vessel to transmit the signal by her fog whistle when obscured by the smoke of battle. It may be readily imagined that some sort of communication between vessels for tactical purposes would be needed in battle under some circumstances, and if flags and shapes are obscured, the fog-whistle offers another means. If shapes are to take the place of flags, then the battle signals should consist of simple characters capable of display in one hoist.

We have in our navy three service codes: (1) a numeral flag code of ten elements; (2) the American Morse alphabet and numeral code, and (3) the original Very three-element or bracket code. We have, besides, three experimental codes in use in the North Atlantic squadron: (1) a new flag numeral code, using yellow in several flags in place of white; (2) the so-called Ardois alphabet and numeral code, and (3) the four-element Very code (originally proposed by Lieut. R. T. Mulligan, U. S. navy). There is as yet no official order prescribing the method of using the American Morse code on the fog-whistle or by gun-fire. Our general signal book contains almost no recent additions of new signals demanded by modern conditions, and is filled with many that are out of date. Surely there are enough questions awaiting some decision or official action to warrant the appointment of a board to consider what is to be done. The new flags possess the merit of great visibility and distinctness, but it should be definitely settled as to three-flag hoists being the *maximum*, and as to battle or action signals being one-flag hoists. Shapes should be experimented with; the Very four-element code should replace the old bracket one; homing pigeons should be regularly adopted as a means of communication; and, above all, the American Morse code should be withdrawn from active service. We have no method of distant day signaling, and distant phonetic signaling is only vaguely alluded to in the Revised Instructions in Signaling, which are issued experimentally.

The old Myer code is the most nearly perfect one in existence. It has been shown, however, that certain practical considerations as

to four lights in a permanent hoist have made it desirable to limit the group of elements in the numeral code to four. Happily, the four-element Very night code offers just the numeral code needed to take the place of the one of five elements used in the old Myer. As applied with the Myer alphabet, it gives us thirty characters in what we may call the Myer-Very code or the Modified Myer code. These thirty characters are capable of transmitting any possible message under every possible condition of service. It is a perfectly well recognized principle of modern signaling that one group of elements (that is, a character) must be allowed more than one meaning or signification. For instance, in the English semaphore code of three elements, the ten numerals duplicate ten letters of the alphabet. In our general flag code, by the use of such flags as the geographical or telegraph, we can give to a hoist of flags several different significations; also, in our wig-wag code, as specified in the instructions in the General Signal Book, we may, by the use of such code calls as G. L. U. or T. D. U., etc., give a special meaning to any signal used.

We may, however, in place of the Myer code use the Continental Morse in the same way, either by calling the dot a 1 and the dash a 2, or by changing the Very numerals to dot and dash, as shown on page 448. This would give us a modified Continental Morse code of thirty characters.

If there is any value in theoretical considerations; if the experience of foreign navies is in any way a guide to us; if what has been here outlined is correct in principle, and of the least practical value, then we should adopt the Modified Myer code for all purposes of signaling. We can use its thirty characters as a wig-wag code for hand flag, torch, winker light, or search light; as a squadron distant code with shapes on a signal mast; as a night code with four double lanterns in a permanent hoist; with the Very stars for a distant night code, and with the fog-whistle and gun-fire in a fog. Abolishing the musical signals in the infantry and artillery instructions, the letters of this code transmitted by bugle could be used, and much confusion and misunderstanding avoided in brigade operations on shore. With only thirty characters to learn for *all* purposes, signaling in general would be much simplified. The same remarks apply to the present night speed-signals authorized by the Fleet Drill Book. With a double lantern (half white and half red,

as in the Ardois) for squadron cruising purposes, on the truck of all our vessels-of-war, there would be no need for using the elaborate yard-arm, truck, and stern lights now carried. No matter how well drilled the look-outs may be, or what rare presence of mind an officer-of-the-deck may develop in any emergency, it is too much to expect that the speed-signals now in use can be properly made in the excitement of a moment. Assume that in steaming in open column (which is the safest formation for night cruising) the leading vessel suddenly develops a danger close aboard. The helm must be put over; both engines reversed or stopped; the steam whistle sounded as to helm signal; if the danger is very imminent, the water-tight door signal must be made; the two white lanterns must be hauled down from the yard arm, and the red light displayed astern. If the halliards jamb, or if the signal is imperfectly made and the vessel next astern rams the leading vessel, then the officer-of-the-deck of the last named vessel is *responsible* for the signal not being properly made, and yet he is not in a position to control the signals in an emergency and keep his attention on the danger ahead. The lights as now authorized are a real source of danger to the vessel carrying them, and they confuse merchant vessels, as every one will testify from experience. In time of war, no squadron is going to advertise itself with *any* lights. It would, therefore, be best in time of peace to practice cruising as would be done in time of war. No permanent display of lights is really needed. Vessels can keep in touch without it, and should be required to do so. A board of officers in the Squadron of Evolution, of which Captain Philip, U. S. Navy, was senior member, submitted a report to the Commander-in-Chief in November, 1891, on the subject of speed signals, as follows:

"1. With regard to day speed-signals in squadron, it would be in the direction of simplicity to abolish the pennant and use only a ball of an improved type, which ball should have four positions. Up at yard-arm, 'going ahead at full speed last indicated by signal;' half-way down, 'backing or going astern;' just above rail, 'steerage way or slow.' Out of sight, 'stopped.' The ball should be larger and heavier than that now used. It could be pierced through one axis by a steel tube working on a wire back stay, the tube working as a traveler. It would come *down* of its own weight. The lower end of the back-stay could be shifted and

set up when the yard was braced (if the yard is movable). The question is the usefulness of the pennant. It is supposed to show relative speed, but it is a deceptive and inadequate device for accomplishing a purpose which can better be accomplished by signaling the exact speed. In the manœuvres off Bar Harbor this summer (1891), if the real speed had been signaled, then there would have been no doubt as to the 'fast speed' intended. The pennant required one or two men to run it. On a bridge of a vessel like the Concord it adds extra men. It can easily be dispensed with.

"2. With regard to night speed-signals, no lights other than the international lights should be permanently displayed. Each vessel should have in position, astern, a red globed lantern containing a lamp, controlled by the officer-of-the-deck from a switch on the bridge. This light should be displayed only in the emergency of stopping and backing. It should signify to the vessels astern 'look out for yourselves!'

"The yard-arm speed-lights (white) are a source of danger, on account of the liability of the halliards jamming, and they do not adequately indicate relative speed. They throw a glare on the bridge, they confuse merchant ships, and require from two to four men to manipulate them quickly. In case of emergency they are one more complication for the officer-of-the-deck . . . The mast-head (truck) light is not useful, as at night the sextant is rarely used to judge distances . . . In time of war, ships would have to keep their position, and keep together without lights . . . (We recommend that) there be placed on the fore and main truck of each ship in commission a double lantern, similar to that used in the Ardois apparatus, and connect the lamps by wires with a key board. The white light should be used as a winker to transmit the Myer-Very code, using the red light for the 'front' to mark intervals between words and sentences and end of message. These lanterns are useful in case the Ardois or other apparatus is masked or out of order; they can never be masked; and they would be in position to use as a white or red truck-light for squadron purposes such as for guard ship, etc. . . .

"We recommend (in place of the white yard-arm lights), in case it is desired to signal, 'we are going ahead a little faster,' flash dots from the white light at the mast-head (truck). In case

a vessel slows down for any reason, flash long dashes with the white lantern which will indicate 'look out, we are slowing a little.' (The red lantern should be used similarly for stopping or backing.) The points aimed at are that (1) no permanent lights should be displayed other than the regular ones, and (2) all other speed and emergency signals should be under the immediate control of the officer-of-the-deck. This point is vital." (Oil lanterns should be kept at hand, lighted and ready for signaling in case of accident to electric plant or truck lantern.)

Let us take the Armored Cruiser New York and imagine her fitted with the latest appliances for signaling, and using the methods of signaling here advocated. She would have two military masts with signal topmasts, each fitted with a set of four collapsible shapes, one set for squadron cruising, about 2¾ ft. in diameter of discs, and 4½ ft. hoist, and the other, 4 ft. in diameter and 7 ft. hoist, for distant signaling. There would be halliards for international flags (since all ships are required to have them), and two signal yards, one on each mast, for hoisting flag signals (international) for such routine signals as might not seem to require the use and wear and tear on the shapes. There would be two sets of permanent hoists of four lanterns, one on each mast, on a stay from the mast-head, so as to show from the port or starboard bow, and from the starboard or port quarter. Each hoist should have its own key board and circuit. On the truck of each mast would be a double lantern (red and white) for a winker light and speed-signals. Each truck lantern would contain two groups of six 12 c. p. lamps, worked from a key on the flying bridge for the officer-of-the-deck and on the signal bridge for ordinary signaling. The steam whistle would be specially fitted with levers, cocks and drains for fog-whistling purposes, and there would be on the bridge an audiphone for locating the bearing of sound signals. Arrangements would be made for homing pigeons for use in squadron manœuvres to be utilized in time of war, and for Very's signals short barrelled shot-guns would be provided for projecting the stars. The signal men would be rated men, petty officers, ranking next after coxswains, and their assistants would be men or boys training to become quartermasters or signal men, receiving extra compensation for such service. They should all be required to know the American Morse code, so as to be able to communicate with army stations when necessary; but it would not be the code

used on board the New York or in the naval service. Thus equipped, this ship would be unquestionably better off in respect to signal code, apparatus and methods than any vessel afloat.

It would be too confusing to go into a detailed description of the method of using the Modified Myer code for all purposes of signaling. It will, however, concisely illustrate the simplicity of the scheme to give here a tabulated outline of it. Every detail is capable of ready explanation, and, while the synopsis in no way explains itself fully, the scheme is all there. It has been submitted officially and awaits the action of the Navy Department.

Code Calls.

1. A. S. U. Action or Battle signals use.	7. C. A. U. Cipher "A" use.
2. I. C. U. International code use.	8. G. B. U. Cipher "B" use, etc.
3. T. D. U. Telegraphic dictionary use.	9. O.N.U. Ordinary numerals use.
4. G. L. U. Geographical list use.	10. C. S. U. Compass signals use.
5. S. B. U. General Signal Book use.	11. V. N. U. Vessel's numbers use.
6. F. D. U. Fleet Drill Book use.	12. N. L. U. Navy list use.

THE MODIFIED MYER CODE ADAPTED TO ALL PURPOSES OF SIGNALING.

Character.	1 Wig-wag.	2 Night Signals. (Ardois.)	3 Special Signification.	4 Very's Code.	5 Proposed Very's Code.	6 Fog-whistle.	7 Gun-fire.	8 Shapes.
A	22	WW			Same as colums 3 and 4, excepting in the use of white for green to conform to column 2.	Same as columns 1 and 3. — The 1 of the Wig-wag is one toot. — The 2 is two toots. — The interval is one blast.	Same as columns 3 and 4 or 3 and 5. — The red is one gun-fire. — The green or white is two gun-fires.	Same as columns 1 and 3. — The 1 of the Wig-wag is a cylinder. — The 2 is a globe or a trapezoid of revolution.
B	2112	WRRW	0	GRRG				
C	121	RWR						
D	222	WWW						
E	12	RW						
F	2221	WWWR	4	GGGR				
G	2211	WWRR	6	GGRR				
H	122	RWW						
I	1	R						
J	1122	RRWW	5	RRGG				
K	2121	WRWR	Negative	GRGR				
L	221	WWR						
M	1221	RWWR	9	RGGR				
N	11	RR						
O	21	WR						
P	1212	RWRW	Affirmative.	RGRG				
Q	1211	RWRR	Interrog.	RGRR				
R	211	WRR						
S	212	WRW						
T	2	W						
U	112	RRW						
V	1222	RWWW	7	RGGG				
W	1121	RRWR	Annul	RRGR				
X	2122	WRWW	Code call	GRGG (Numeral)				
Y	111	RRR						
Z	2222	WWWW	2	GGGG				
Cornet.	1111	RRRR	1	RRRR				
Letters.	1112	RRRW	3	RRRG				
Numerals.	2111	WRRR	8	GRRR				
Interval.	2212	WWRW	Interval	GGRG		Blast.		

DISCUSSION.

Lieutenant R. T. Mulligan, U. S. Navy.—It is not my intention to enter into any criticism of Lieutenant Niblack's very comprehensive article on Naval Signaling, or to discuss the merits or demerits of the various *systems* and *codes* used by other nations, which he has so fully described. I shall confine myself to the *systems* and *codes* now authorized by the Navy Department for use in the United States Navy, and, if possible, offer certain suggestions as to changes or modifications in them.

I fully endorse Lieutenant Niblack in all he has said in condemnation of the American Morse Code for naval signaling, and concur with him in believing that the naval service almost demands an immediate return to the old Myer Code, modified in the direction of simplicity.

The disadvantages of the present "Army and Navy Code for Visual and Telegraphic Signaling" can only be fully appreciated by those who have had practical experience in its application to fog-signals. The only instructions, authorized by the Department, for a system of fog-signals will be found upon pages 13 to 15, inclusive, of the General Signal Book, and experience has long since proved that these instructions, even when applied to the old and almost perfect Myer Code, have failed and have fallen into disuse, being impracticable and cumbersome. Following the instructions on page 15, General Signal Book, it would take an expert signalman 6 minutes and 15 seconds to signal, "Course S. W."

In consequence of this, signal officers have, from time to time, been called upon to improvise a system of fog-signals which depended upon the *ear* and not the *watch* for its successful operation. A *time* element is dangerous and should be avoided in *any* system. As it is impossible to use the American Morse Code without the introduction of a *time* element, this is a sufficiently good reason for its being abandoned. When you attempt to apply it to the fog-whistle confusion becomes worse confounded. The *fourth* element of this code has two meanings: it may either represent a *space* or a *front*.

The advantage of the Myer Code is its extreme simplicity; it is a code of but *three* elements, and is constructed upon sound and simple principles. The *time* element is eliminated. It can be applied to the wig-wag (flag or torch), heliograph or flash lantern, fog-horn, steam whistle, bell, gun-fires, Very's Night Signals, or the "Ardois Alphabet," and to all with equal facility and certainty. The present "Ardois Alphabet" is cumbersome, and it is an *additional code* to be learned, there being no connection between the displays and the *dot* and *dash* of the American Morse Code.

The system of numerals proposed for the Myer Code is excellent; it fits in with a modified Very's Code.

My idea of flag signals is that no tactical or general signal should consist of more than three flags. By making use of the *zero* and three *repeaters* in the numeral code we have 13 one-flag signals, 156 two-flag signals, and 1716 three-flag signals, making in all a total of 1885 displays or permutations.

I am of the belief that the present tactical and general signal books can be reduced to this number of signals. It requires but a glance at any page in the General Signal Book to see what a large percentage of these signals can be stricken out without reducing its efficiency. These signals should be arranged and grouped so that those of urgency and importance would contain the least number of flags or shapes, and should be bound in one small book. The Telegraphic Dictionary and the Geographical List can be expanded to any extent; they should be as full and complete as possible, and should be bound in a separate volume. These signals need never go beyond a four-flag hoist.

I do not believe in a *flag* alphabet. By increasing the number of flags or shapes (elements) you increase the chance of making an error in each signal. Our present code (proper) consists of thirteen (13) elements, and I am firmly of the belief that with it we can make all the signals that will be necessary for the handling of a fleet and its dependencies in time of war.

If we give up this code and adopt one having 26 elements (a flag for each letter of the alphabet), we will have, in accordance with the theory of chances, in every one-flag hoist twice as great a chance of error, in every two-flag hoist *four times* as great a chance of error, in every three-flag hoist *nine times* as great a chance of error, and in every four-flag hoist *twenty-one times* as great a chance of error.

The navy needs a simple code that can be easily learned, and one in which the chance of personal error is reduced to a minimum. The proposed *flag* alphabet does not fulfill these requirements. Let us simplify the present system and not complicate it.

Very's system for *distant* signaling is excellent. The code adopted by the Navy Department is a bad one. It can at once be improved by representing the numerals by groups of four (4) stars, elimination of all brackets, and the introduction of an *interval* or *space* to separate words in a telegraphic message, etc.

If the stars were loaded in metallic shells and fired from a short double-barrelled breach-loading shot-gun, a great deal of time could be saved. The one great objection to Very's system is that it is slow.

In conclusion, I will simply state that I am of the belief that a modified Myer Code, which can be applied to the wig-wag, a modified Ardois Alphabet, a modified Very's Code, and fog-signals, would give satisfaction to the entire service.

Lieutenant H. P. Huse, U. S. Navy.—I have been very much interested in Lieutenant Niblack's excellent paper on signaling, and what remarks I have to make on it are supplementary rather than critical, and are confined to visual signaling.

Two systems of visual signals are necessary for the service, a day system and a night system; and two codes are necessary, a long-distance code and a short-distance code. This gives us four classes of visual signals; but the matter can be simplified if we use the same code for day and night short-distance work, and a second code for day and night long-distance work.

If we consider apart all signals which can be projected to a great altitude, like rockets and Very's signals, it is not difficult to reduce the question to this form, and then, I think, that most officers who have had much practical experience in signaling on board ships at sea will agree with me that the short-distance code should be based on what Lieutenant Niblack calls transient signals, while the long-distance code would better come under the head of permanent signals. If this is admitted the problem is simplified.

Short-distance Signaling by Day.—The objections raised by Lieutenant Niblack against the wig-wag are only too familiar to us. Whoever has had to send a message to several ships, no two of which could read the same signal, has felt the want of an all-around system. In fact, the short-comings of the wig-wag are so great that the flag and the torch will, it is hoped, soon be relegated to the class of only possible accessories in ship-signaling.

In 1889 Lieutenant Benson suggested to me the use of collapsing shapes, and experiments were carried on in the N. A. Squadron, first on board the Baltimore, and afterwards on board the Philadelphia, with a view to discovering the possibilities of such a system. A cone and a cylinder, each about two feet high and made with barrel hoops and bunting, were the primitive means at my command. The shapes were exposed and collapsed by means of endless signal lines and small blocks, so rigged that when the shapes were triced up aloft, a downward motion on the lines exposed the shape, and an upward motion collapsed it. The signal was sent by one man, who worked one shape with each hand. The rapidity of work was about equal to what could be done with the small wig-wag flag. The signalman had complete control of the situation, and could make a signal visible all around the horizon. Signals made to the Petrel, about half a mile off, were read without difficulty by apprentices, who had had no practice except with flags. It is to be observed that with two collapsing shapes five elements can be conveniently used. The result of the work was to satisfy me that with carefully constructed apparatus the system would prove successful. The difficulties I encountered were that the shapes were too small, and that the bunting of which they were made jammed in the blocks. Other duties and my detachment from the Philadelphia interfered with further work in this direction at the time. The code used was that embodied in Lieutenant Niblack's paper on page 471.

Short-distance Signaling by Night.—I think Lieutenant Niblack is right in his criticisms of the method used for night signaling in the N. A. Squadron in 1890 and 1891. It was found to be too slow, though very reliable. The green light is not an essential part of the system, however, and I still think that, in the event of the temporary or permanent failure of the more complex arrangements of lights required in such systems as the Ardois, the ship whose signaling outfit was thus disabled might find this simple system a great convenience. A fully equipped key-board costs only $30; the lights are the ordinary electric deck lanterns furnished. The system was first suggested to me by Lieutenant Benson.

Long-distance Signaling by Day.—I agree entirely with Lieutenant Niblack in nearly all that he says about the use of flags for signaling, but I think his suggestion, that we follow the example of Italy and adopt the international code flags, is open to criticism. In a complete system of signals, submitted to the department by Admiral Gherardi and briefly referred to by Lieutenant Niblack, a whole system of flags was designed on the following principles:

1. The colors best adapted for the purpose are blue, red and yellow.

2. The design of the flag and not the colors should distinguish the flag, *i. e.*, the colors should serve only to mark the design.

3. Consonants should replace numbers. It was found necessary in the development of the system to introduce one additional flag (A) as answering and affirmative pennant.

4. There should be no top and bottom to a signal flag. That is, the flag should be symmetrical in construction and design with respect to a line perpendicular to and at the middle point of the hoist.

The object of not having the color a distinguishing feature of the flag was not that signals might be read by the color-blind, but because there are conditions of light and distance when it becomes impossible to distinguish between even red and blue, and both appear simply dark, although the line of demarcation between two colors can clearly be seen. Thus at sea at midday I have seen a signal in which it was absolutely impossible with the best glass in the ship to tell whether a certain flag in the hoist was five or six. Finally the signal quartermaster was positive that it was five; it proved afterwards to have been six. The ship was the Galena, and I was the signal officer.

Anyone who has tried to do fast signaling knows the annoyance of getting hold of the downhaul of a big signal flag when he wants the hoist to hook on. It is essential to quick work that there should be no difference between the two; the top should be the end the signalman gets hold of first. Both ends should, of course, be clearly tagged.

The advantages of a system of flags designed on these principles should outweigh any small advantage to be derived from adopting the international code flags. It would, of course, be convenient to have only signal flags belonging to one code for all purposes, but the difficulty of making out some of the I. C. flags at a long distance, and the danger of confusing such letters as P and W, when the flag is not blown out clear, should of themselves be sufficient to condemn them.

The size of signal flags now issued to ships for general signaling is too large for ordinary squadron work and too small for distances above three to five miles. Two sizes might better be used, the smaller size for squadron evolutions, etc., when speed is sometimes of great importance; the larger for long-distance work, as communicating with outlying vessels on scouting duty. In this connection I may say that the very important question of sufficient altitude of masts and signal yards to admit of sufficient hoist for signals seems to have been overlooked in the design of some of our new ships. In the Baltimore this had to be remedied as soon as she

became a flagship. On none of the new ships that I have seen is there any evidence that in sparring and rigging them the question of signaling facilities has been considered as a matter of primary importance, not a *peace* importance either, but a *war* importance.

Lieutenant Niblack has so completely covered the subject of long-distance night signaling that there would appear to be little left unsaid. I can only add that the Very system, using the four-star code, always worked satisfactorily in the N. A. Squadron in 1888–1889, provided the pistols were not worn out, the cardboard cartridge cases not too much swollen to enter the chamber, or the stars not so defective that occasionally one failed to ignite at all, or did so a few feet above the water, leaving the sender in doubt whether he should fire it over or not. But with a simpler pistol on something like the old Remington model, with metallic cartridge cases, and with careful laboratory work, the Very system, with the four-star code, leaves little to be desired in the branch of long-distance signaling for which it is best adapted.

The subject of a code and the much broader subject of the general arrangement of the signal book are very tempting, and I should like to discuss them in this paper, but as an appendage to another paper it is already long enough. I must, however, call attention to the fact that much greater speed than is given by the Myer code can be obtained by using five elements instead of three, and that five elements are at our command with two lights of different colors or with collapsing shapes. A return to the Myer code would, in my opinion, be a wrong step, as it is distinctively slower than the American Morse now in use. The American Morse has never, to my knowledge, given trouble which has not been due to the inherent defects of the wig-wag system.

Lieutenant W. F. Fullam, U. S. Navy.—Lieutenant Niblack treats the signal question so exhaustively and so practically, that little remains to be said except to comment upon the facts that are cited and the conclusions arrived at in his paper. It is conclusively proven, in this searching examination of the subject, that, in passing from the Myer to the Continental and then to the American Morse code of wig-wag signals, the navy has progressed steadily backwards during the past six years. That the army had good reasons for making these changes may be admitted, but that the navy, in following the army, grasped the shadow and lost the substance of this important matter, is clearly demonstrated.

There is, perhaps, a certain advantage in having the same code of signals in the navy as in the army, but this principle is greatly outweighed by several others, each of which is of far greater importance. The result is, therefore, that we have followed a theory based upon a single, and not very important principle, and in so doing we have neglected many practical considerations, and violated the true and vital principles that should govern the selection of a code for the use of the navy. Lieutenant Niblack has shown, beyond question, that the conditions and requirements afloat and ashore are so different that the navy should develop or select a system of

signals that are suited to its own peculiar uses. In other words, the navy cannot rely upon the army to think for it in this matter, nor can it successfully bully Nature's laws and ignore service conditions by pursuing a course that rests upon one lone idea—that of having the same code as the army.

The fatal defects of the American Morse code, and the fact that it cannot well be adapted to naval conditions, are made glaringly apparent in this paper. That the space or time element is a serious objection will be admitted by those who are called upon to read signals by this code. It is far easier to read signals by the Myer code, and surely we should have the code that renders the reading of signals as easy as possible. The difficulty of using the American Morse code with the steam whistle, the fact that it cannot be adapted to a system of night signals like the Ardois, and that a hoist of six lanterns would be necessary "to transmit the numeral *six*," are reasons enough to show that this code is totally unfit for the navy.

It is almost amusing to note the predicament in which the navy finds itself as a result of the adoption of the American Morse code. Lieut. Niblack states that "the American Morse code *cannot be used in the Ardois*, and in our service we have a *special code* called the 'Ardois' to use with the apparatus." In order, therefore, to communicate effectively with the army *at night*, the latter *must learn the Ardois code!* In other words, by adopting the American Morse, we have not even facilitated nor simplified the means of communication between the Army and the navy. *Both the army and the navy must now learn two codes!* The attempt to make one code answer is a failure—this one lone, shadowy principle, with which we have flirted, has jilted us.

On the other hand, had the navy adopted a simple and practical system —*one that could be adapted to all purposes of naval signaling, by day or night*—the army would have been put to no more inconvenience than at present, and the navy would have gained immensely *in having but one code to learn in making its own signals*. In fact, the army might also have gained, because the system that would be adapted to naval purposes would probably be simpler and more easily learned than the Ardois code.

It is hardly proper for one who has had no practical experience with the Ardois system to attempt to discuss its merits or defects. But it would appear, from Lieut. Niblack's paper, that the Ardois alphabet is by no means a good one, and that there are many serious objections to a system that requires five lights in a hoist when it would be possible to get along with four. When we consider the restrictions as to height of masts that are imposed on board small ships, monitors and torpedo-boats, it is clear that the fewer the lights the better.

Lieut. Niblack's treatment of the subject of speed and other signals used at night in squadron cruising, is very much to the point. If squadrons must manœuvre with few or no lights in time of war, officers should be prepared for such an emergency in time of peace. An officer who has always been accustomed to cruising in a squadron loaded with lights, like a torch-light procession, will experience a violent change passing into the

conditions that obtain in time of war. An officer-of-the-deck who must direct the helm, control the engine, watch the other ships, and at the same time see that three or four men hoist or lower as many lights or signals, may avoid disaster in an emergency, but it will be more by good luck than good management.

"The simpler the whole question of signaling can be made, and the fewer the codes which men have to learn, the better we will get along, as we have no corps of trained signalmen, and we require practically all our officers and men of the active combatant force to be up on signaling." This sentence sums up the whole matter, and Lieut. Niblack's plan of a modified Myer code, that can be "*adapted to all purposes of signaling*," is the true and only practical solution that has yet been proposed.

With "three service codes" and "three experimental codes in use in the North Atlantic squadron," with no official method of using the American Morse code on the fog-whistle, with no method of distant day signaling, and with a general signal book that is twenty years behind the times, it would indeed be difficult to imagine a condition of greater confusion and inefficiency than now exists in the United States Navy in the matter of signals. Under such circumstances, with important questions unsolved, with a multiplicity of codes, and poor codes at that, it is not surprising that many officers and men find themselves in in a state of complete bewilderment as regards signals. It is probable that there are now fewer officers and men who are competent to make and read signals than ever before in the history of the navy. Certain it is that the subject has never presented to them so many difficulties as at present. It may well be asked whether the navy can be considered in a state of readiness for war, with the signal question in its present condition? If this question can be answered in the affirmative, it follows that signals are of very little importance in the navy and have very little to do with the proper conduct of naval movements or operations in time of war.

Lieutenant J. M. Bowyer, U. S. Navy.—I have read with much interest the able and carefully prepared article on Naval Signaling, written by Lieut. A. P. Niblack, U. S. N., and I congratulate him upon his masterly treatment of a subject that has not heretofore received the attention that it deserves.

The changes made in recent years have not all been beneficial. I refer particularly to the changes made in the wig-wag code.

Among the officers of the navy we have lost, by a process of elimination, due to changes of code, a large number of qualified signal men. When I made my first cruise, the officers of and above the grade of master, as a rule, could not read or make wig-wag signals, the reason being that the code had been changed since they learned it. My impression is that the change referred to was made in 1870, and, although only a slight one, it was sufficient to practically disqualify a large number of officers.

It is important that all line officers should be able to use the wig-wag; but since 1870 about fifteen classes, representing more than 500 officers, have been graduated from the Naval Academy qualified in the Myer code,

only to be disqualified by the adoption of the Continental Morse, and those that learned the latter were, in turn, disqualified by the adoption of the American Morse.

The numerous changes of code would not matter so much were it not that it requires much practice to become proficient in any code, particularly when one has to forget a code or codes already learned.

I believe that the Modified Myer code, as recommended by Lieut. Niblack, would prove excellent for all purposes of signaling. The American Morse, so long as the army clings to it, would have to be taught to the signalmen.

Regarding shapes, I consider them excellent on board large ships when not engaging an enemy; but in battle, presenting as they do a large target, they would become worse than useless, because the enemy's fire would inevitably derange them so that either they could not be expanded, or, being expanded, they could not be collapsed.

I therefore favor a *preventer* set of flags, made to take the place of the shapes, for use when the latter become impracticable, *i. e.*, when they become jammed in action, and in small craft where they cannot be conveniently used.

Captain J. W. Philip, U. S. Navy.—Lieut. Niblack's article . . . has interested me very much, and I agree with him in his conclusions. The Myer code, with the proposed modifications, seems to me the best for adoption for all of the methods of communication. The adoption of shapes instead of flags, the masthead light, and the elimination of the fifth light in the Ardois system, are also in the line of improvement. I have asked the Department that there be placed on the fore and main trucks of the cruiser New York a double lantern, similar to that used in the Ardois apparatus, the lamps to be connected by wires to a keyboard. These lanterns are useful in case the Ardois or other apparatus is masked or out of order; they can never be masked, and would be in position for use as a white or red truck-light for squadron purposes, such as guard ship, etc.

Lieutenant T. B. M. Mason, U. S. Navy.—The lecturer certainly deserves our thanks for the intelligent way in which he has handled his important subject, and for the fearless way in which he has pointed out the defects in our present methods of communication.

He is undoubtedly correct in advocating the adoption of a four-element Myer code. The old code is the best that we have ever had, and the proposed elimination of the fifth element is a vast improvement.

The Myer code is equally adapted to the best methods of sending day and night signals now known, either visual or phonetic. That it does not correspond with the codes used in ordinary telegraphy seems an advantage, as it could be used by signalmen without being intelligible to civilian operators. A written message in the code characters could be sent or taken down in writing, on receipt, by any ordinary operator.

It would be a great improvement to use the same code with all our instruments for communicating, thus doing away with the necessity of

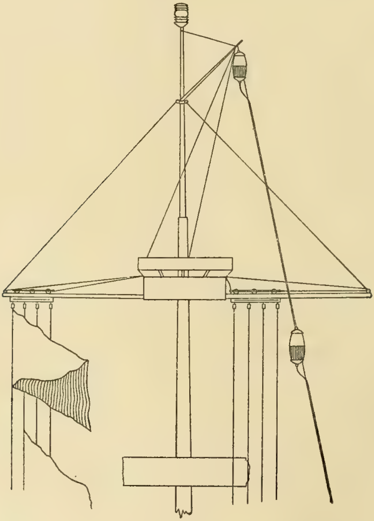
teaching our signalmen half a dozen different codes. When we had the old Myer code we had plenty of good signalmen; now we have but few, and even those are not proficient in all of the codes and often become confused.

That a distant all-around signal should be made from the highest point of the station is undoubtedly true, and an arrangement of masthead lights and shape signals absolutely necessary.

I quite agree with the lecturer in his conclusions as to what we need, and sincerely hope to see the whole subject placed in the hands of some officer of modern experience who can evolve system out of chaos and pull down our present tower of Babel.

The findings of the Philip Board will certainly be approved by every officer who has had charge of a modern ship sailing in squadron.

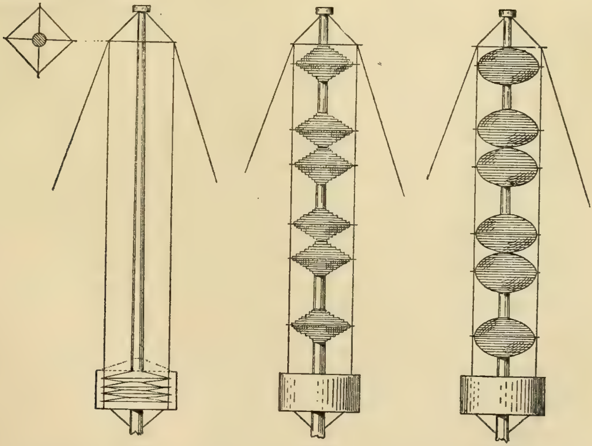
The subject of carrier pigeons is one of vast importance to us, and the service owes its thanks to those who, almost entirely unaided by the government, have succeeded in making a beginning in establishing such means of long distance communication. A single bird, reaching land from an outlying picket vessel might give timely warning of an approaching enemy, allow of a concentration and save a city.



The New York is to be fitted for masthead signaling and could easily be fitted to display the shape signals. The above sketch shows her present signal equipment.

Lieutenant W. IRVING CHAMBERS, U. S. Navy.—I have given this subject considerable thought and agree with the writer on all the essential points. I have also conversed with many officers who have had recent experience with the confusing system of signals in present use and, without exception, the opinions expressed have favored a return to the Myer code. Give us that code, and the details of using it under all circumstances will readily follow.

I venture to disagree, however, on a minor point, where (p. 448), in a spirit of fairness, the writer wishes to point out "one rather serious defect in the Myer." Having had an exceptional amount of experience in signaling with the Myer code by fog-whistle (on board the steamship Loch Garry, with the Greely Relief Fleet, where I had personally to attend to all the signaling, very much of which was in fog or thickly falling snow), I can stoutly affirm that no such defect exists, if we regard 1 as a *blast* (of any duration) and 2 or 3 as two and three *toots* respectively. In this case Y is simply 3 blasts, and "front" (or interval) 3 toots; N is 2 blasts, and T is 2 toots. It is very easy to make this distinction between a group of toots and a blast, and my experience teaches me that if the sounds, toots or blasts, are of equal duration, the result, especially with a "*smart* signalman" who is trying to show off, is a confusing succession of sounds improperly spaced.

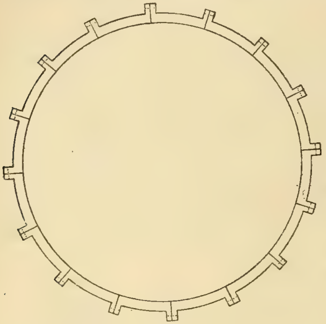


(*d*). (*a*). (*b*).

In regard to the proposed arrangement of shapes for distant day visual signaling, I think practice would demonstrate that the varying effects of atmosphere and light would frequently so distort them as to render it difficult to distinguish the difference between the two, and that the

mechanical difficulties of the arrangement of two shapes in one would prove too great for smooth working. I would, therefore, suggest that the shapes be *all alike* and *double*. Figures (*a*) or (*b*).

For all collapsible shapes I would prefer some such preparation as oiled silk to rubber, on the score of durability, and should wish to arrange the covering so as to prevent access of water to the springs and joints. The difficulty of mast construction would enter as a factor. We would need light masts with about sixteen grooves, and this difficulty could perhaps be met by making the small masts as shown in figure (*c*). The flanges should be flush riveted.



(*c*).

This, to my mind, is the best method of construction for *all* military masts; but that is somewhat outside of this subject.

I fancy, however, that the simplest and best (though perhaps the slowest working) arrangement of signal shapes would be that whereby the shapes were *wholly hoisted* at each display, and such device might be tried on any mast of sufficient height. Figures (*a*), (*b*) and (*d*).

The double shapes would require a little greater length of mast than the single shapes, and the hoisting shapes a little greater length than fixed shapes, but a mast 50 feet in clear would amply suffice for double shapes of 4 feet diameter.

I do not think that torpedo-boats or torpedo hunters should be provided with Ardois lanterns, but should be required to rely upon the flashing masthead lantern which all ships should have. The most important war or lookout warning signals should be arranged to be transmitted by one lantern in the shortest time.

I think the thanks of the service are due to Lieut. Niblack for the zeal and patience he has displayed in following up this subject, which is of rapidly growing importance.

Commander C. M. Chester, U. S. Navy.—It is only necessary for one to have attempted to study the subject of signals in the navy to comprehend the vast amount of labor that has produced the excellent paper of Lieut. Niblack.

Assuming that we are to retain our woefully complex system, which has resulted in the common practice of making a signal to "send a boat," and then returning the message by a bearer of dispatches, the propositions of the lecturer become valuable. Indeed the paper is full of valuable suggestions for any system of signals, but what I would impress upon the Association is that our present code of signals is entirely inadequate to the growing demands of the service.

The U. S. Navy Code of Signals consists of 10 elements, represented by 10 digits, which, combined in groups of 4, allow 9999 signals to be indicated. As our signal book contains many more than this, we resort to repetition of numbers, qualified by a pennant or signal to go before. Should the pennant be obscured, as it frequently is, a signal sent to "Ram the enemy at full speed" may be interpreted "How," or the reverse. In order to make all the possible combinations of the signal code, we use at the present time 31 flags. This cumbersome system has resulted, as I have said, in sending messages by boats, rather than as signals, and thus preventing the practice in signaling which is an absolute necessity for preparation for battle.

In 1889 Commander C. H. Davis proposed an entire new departure in signals, based upon the system of the International Code. His communication was referred by the Department to the Board on Organization, and, after a careful investigation, its adoption was recommended.

The system contemplated the use of 20 elements, represented by 20 consonants of the alphabet. It is only necessary to work out the permutations possible, to show that over 116,000 signals can be made with four flags, or other symbols; ample to accommodate any code, without repetitions.

The great advantage claimed for the system is that no combination of flags can have a double meaning.

Having been detailed by the Bureau to prepare a new code of signals, on the basis of the recommendation of the Board of Organization, I worked continuously on the subject for over a year, and submitted to the Department what was to be known as the "Introduction to the Code" and the "Fleet Evolutions," and left the "General Signal Book," partially completed, in the hands of Lieut. John F. Parker, in April, 1891.

As the most difficult part of signaling takes place during the night, and as at this time communication is generally more necessary, the code was prepared to cover these requirements, knowing that day signals would easily be assimilated to the night code.

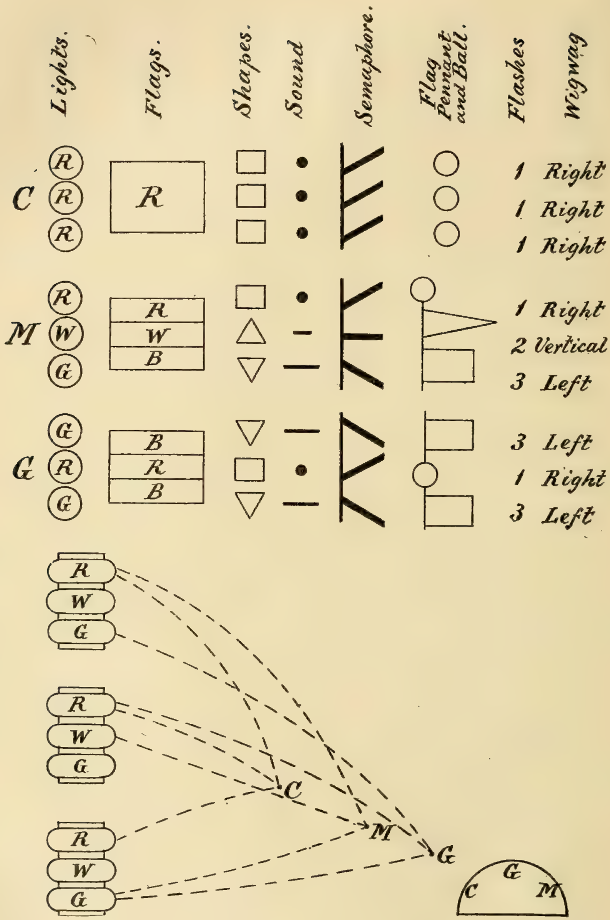
In the proposed code the object has been to combine the fewest number of elements that will contain all the symbols used, without *repetition*, for in repetition there is danger.

It is apparent that two elements, which make only nine combinations in permutation, cannot be used; but that three elements, permitting twenty seven combinations, will suffice for all the requirements of the service.

It is made mandatory that all signaling in the navy should be done by the Navy Code, thus insuring the facility in its use necessary in war by constant practice with it in time of peace.

The following sketch will illustrate the method of using the various symbols in combination, and it is readily seen that any three dissimilar objects may be utilized.

It is hardly necessary to go into a description of the code, but by permutation the three elements, called, say, red, white and green, represented in any way desirable, enable us to make the twenty seven letters of the alphabet. Taking twenty of these for the code proper, we have six letters left for the qualifying signals, "Interrogatory" and "Preparatory" (the



only two used), and the "Answering," "Annulling," etc. The "&," or 27th letter, has a special signification, described in the "Introduction to the Code."

The "Signal Book" has three parts, besides the introduction.

The "Fleet Evolutions" contains:

1st. 20 "Battle Signals," indicated by a single flag.

2d. 380 "Evolutionary Signals," indicated by a hoist of two flags each.

The General Signals are all made with three-flag hoists, and the book has a possibility of 6840 signals; a larger number than in the present signal book.

The Telegraphic Signals are made with four-flag hoists, and there can be made 116,280 signals. Thus additions to the present Telegraphic Dictionary may be made and its scope greatly increased.

The General Signal Book contains a numeral table, similar to that in the International Code, so that any number may be expressed by the letters of the code.

There are, however, ten auxiliary symbols, used to indicate the nine digits, shown by pennants in the day signals, and by two lights at night. The "Zero" and "&" are identical.

Thus messages in numerals may be sent, without the numeral table, although, where confusion from long distance or other causes are likely, they would not be used.

The night signal method, described in the "Introduction to the Code," consists of three electric lanterns, each with a red, white and green shade, arranged vertically, with nine wires, leading to a keyboard, containing the twenty seven letters and ten numerals. The key indicating a letter closes the circuit for one color in each of the three lanterns, while that for a numeral shows two colors, in the same way. The search light is used by showing one, two or three flashes, corresponding to red, white or green of the code.

The sound signals are, dot, short dash and long dash.

The wig-wag, as right, left, vertical, corresponding respectively to the red, white and green of the code.

A very imperfect description from memory of the proposed code has been given, but I will have accomplished my object in taking part in this discussion if the necessity of discarding the old system, with the old ships of war, be shown and substituting something else for a different class of vessels. This, I think, is better than to rehabilitate the old Myer code, as suggested by Lieut. Niblack.

A prime feature of the proposed navy code is the use of shapes for distant signaling, as well as for use on board the low, mastless vessels, which are likely to be common in the future.

I worked for some time over an idea by which the three shapes, square, cone, and inverted cone, could be displayed mechanically on a hollow iron mast, from a turret, but other duties prevented my completing the project.

The semaphore symbols of the code can be easily worked this way, and even this is better than trying to hoist the 4, 5 or 6 flags necessarily used

at present. It may be said that the three colors taken as the basis of the new system are objectionable, particularly in the Very code, and yet Mr. Very himself has recommended their use, and the Italian navy has adopted his recommendations.

The changes made from the Myer code to the English Morse, and later to the American Morse code, were properly made to accord with the army, that we might communicate with that branch of the service, when necessary. In doing so we have almost lost sight of the fact that we have a navy code, upon which we must rely in war time, and which, by disuse, will have become of little value. I would keep the American or English Morse or Myer code to talk to our army friends, as we would send a telegraph message (through an operator), but it should be held as almost a misdemeanor to communicate with our sister ships in anything but the language we shall use during battle.

The drills in signaling should be as rigid as the requirements of the old spar and sail exercises.

Lieutenant H. S. Knapp.—The paper given us by the writer is an excellent presentation of the inefficiency and insufficiency of the present means of signaling in use in the navy, together with a remedy therefor. Every officer who has been cruising recently can testify to the confusion resulting from the use of our many different codes, service and experimental. Every officer, from admiral to cadet, *ought* to be able to understand any signal that he can see, or hear; and if we had a systematic code, carefully and consistently worked out, it would not be too much to expect of any officer that he should be familiar with all sorts of signals. As it now stands, one needs the memory of a Loisette to remember all the codes with which we are burdened.

From personal experience, I can heartily endorse all that Lieut. Niblack says regarding the shortcomings of the American Morse code. Without criticising the reasons that led to its adoption, I unhesitatingly express the opinion that it has been shown painfully cumbersome and inadequate to naval needs. It is harder to learn and more difficult to retain, and it is distinctly slower than was the Continental Morse or the Myer. In doing away with it, however, I am disposed to favor a return to the Continental Morse rather than to the Myer, and for two reasons: first, an army signalman learning the navy code, or a navy signalman learning the army code, would have many less letters to learn over, owing to the duplication of sixteen letters in the two Morse codes; secondly, it would be possible with it to communicate with foreign ships using the same code. It is worth while getting as close as possible to the army in the matter of signals, though it is quite unnecessary to adopt a code for the simple reason that it is the one in use by the army; and the desirability of a common signal code in combined operations with the naval force of other nations, a not infrequent occurrence, was proved during the time that our service used the Continental Morse. Lieut. Niblack himself shows that the Continental Morse can be used in the same way as

he proposes to use the Myer. Either would have to be *modified* to make it a four-element code, and either gives thirty characters when so modified. With the universally accepted convention that the dot is indicated by a motion to the signalman's right, and a dash by the motion to his left, the rest of the general scheme works itself out as well with the Continental Morse as with the Myer.

The scheme is a valuable one as showing that a consistent code can be evolved for all purposes. I have never made any special study of flag or shape codes, and do not feel competent to criticise the changes in these regards proposed in the paper. But I venture to express the hope that, when a code shall be finally adopted, as much attention be given to the instruction of officers and men in general and night signals as is now devoted to the wig-wag. My experience goes to show that most of the instruction given afloat in signals is in the use of the wig-wag code.

That the Ardois, or some similar, apparatus has come to stay there is little doubt. Lieut. Niblack claims for it the advantages of "rapidity and accuracy in signaling." The latter point is freely granted, and the value of that sort of apparatus for night work is unquestioned for that reason if for no other. Moreover, its range is very considerable. I doubt, however, the practicability of its use on low-masted vessels, and consider the use of either the modified Continental Morse or Myer code with the two-element truck-lamp, fitted with Fresnel lenses, the best substitute for it. As a "preventer" on any ship these truck-lamps should always be fitted. I believe that, with a proper keyboard and an arrangement whereby a reduced current could be made to flow constantly through both lamps, sufficient to keep them at a low red heat while signaling, nearly or quite as great speed could be attained as with the Ardois, though not with the same certainty of the signal's correct reception, of course.

The report of the Philip Board concerning night speed-signals and Lieut. Niblack's remarks thereon appeal to every watch officer. To say that the present regulation speed-lights are a nuisance is to state the case mildly. To be of any value, they should be electric lights (during the time I was attached to the Squadron of Evolution one ship used oil lamps habitually, and as habitually the officers-of-the-deck of the other ships placed no dependence whatever upon the display); also, to be under the immediate observation and control of the officer-of-the-deck, they should hoist from or near the bridge. But in that situation, the glare resulting is a serious source of danger. A squadron is not on dress parade at night; every purpose is gained when the vessels keep in good touch—near enough for mutual support and to be well in hand by the Commander-in-chief, and far enough apart not to endanger one another. These objects can be attained without speed-lights and the lights should go. We ought to discard them in peace and so gain the experience and confidence in night squadron sailing under war conditions that would be of utmost importance in case of actual hostilities.

[NOTE.—Should any members of the Institute desire to add to the discussion of this paper, an opportunity to do so will be given in the next issue of the PROCEEDINGS, in which Lieutenant Niblack will reply to the discussion.—ED.]

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

CRUSHER AND CUTTER GAUGES FOR EXPLOSIVES.

By W. R. Quinan, Member U. S. Naval Institute.

The subject of explosives is one upon which we need light. Though in the last two decades we have made some progress in their study, our theories are still disjointed and incomplete. The first assured step in this progress, as indeed every subsequent step, has been gained by subjecting explosives to scientific tests and measurements. Means of measuring mass, time and space have been the three agents of progress. One of the recent contributions to this good work is a paper by Lieutenant Willoughby Walke, 2d Artillery, instructor in charge of the U. S. Artillery School Laboratory, published in the Journal of the American Chemical Society, Vol. XII, No. 7, Sept. 1890. This paper, whatever may be its defects, has the merit of being perfectly impartial. Lieutenant Walke has no particular explosive to exploit. It is to be hoped that he will continue his investigations. In making his experiments he "decided to use the Quinan pressure gauge, both on account of the degree of accuracy with which it registers the pressure, and because of the ease with which the apparatus is manipulated."

In the description which originally presented this instrument to the public, no originality was claimed for it. The apparatus in other forms had been used by other experimenters. So far as I know, the first description of such an instrument used for testing high explosives was published by the late Henry S. Drinker (see "Tunneling, Explosive Compounds and Rock Drills," page 77); so if there is any credit due, it should go to him. Especially so, since with this instrument he demonstrated beyond a doubt the cardinal principle of modern dynamites, viz., that an explosive dope adds materially

to the force of nitro-glycerin, a fact which had been disputed by Mowbray and received no countenance from Hill, Trauzl or André (see pages 71 and 72).

Out of deference to Drinker, my apparatus was called also a "pressure gauge." The better term, "crusher gauge," will hereafter be used.

The Drinker gauge can be succinctly described in his own language as follows, omitting the references to the drawing: "A third apparatus was tried, which we will term a pressure gauge. It consisted, as shown in the figure, of a vertical steel pin 6¾ inches long, 1½ inches in diameter, enlarged at the top to 4 inches. This pin weighed 8½ pounds, and it slid vertically (through a hole) in an iron block, which block was bolted to an iron foundation weighing some 1200 pounds. The pin rested upon a small truncated cone of lead which itself rested upon the foundation." We will add that the block was recessed under the pin so that the lead plug could be manipulated; also that the top of the pin (or piston) was flat, and the *shot* had a recess or cavity to make room for the charge.

The objection to Drinker's gauge for regular work is that the piston is too light, and gets jammed by upsetting. There is also some risk, as the explosive is not confined by a cavity in the piston, but is liable to get scattered on the flat surface. Liquids cannot be tested at all.

The following description of the Quinan gauge is republished, so that the discussion which follows may be intelligible to the general reader.

Pressure Gauge.

"Guided by this reasoning I was lead to adopt, as my test for the higher grades, the instrument misnamed the 'Pressure Gauge,' in which the force of the powder is measured (indirectly) by the compression of a plug of lead. I do not pretend to any originality in this apparatus, as similar instruments have already been used for this purpose. (See Drinker on *Tunneling*, page 77.) The particular form, however, devised by me, having been tried by many hundred experiments, and having proved satisfactory in every respect, merits, I think, a detailed description.

As shown in the drawing (Fig. 1), it consists of a heavy block of wood, upon which is bolted a cast iron block or base. In this base are inserted four wrought iron guides, or standards, set around

the circumference of a four-inch circle. The lead plug rests upon a steel disc (not apparent in the drawing), which is let into the iron block flush with its upper surface. A ring holds the guides in place at the top, their ends being reduced to screw-bolts, passing through the ring, which is held down by nuts.

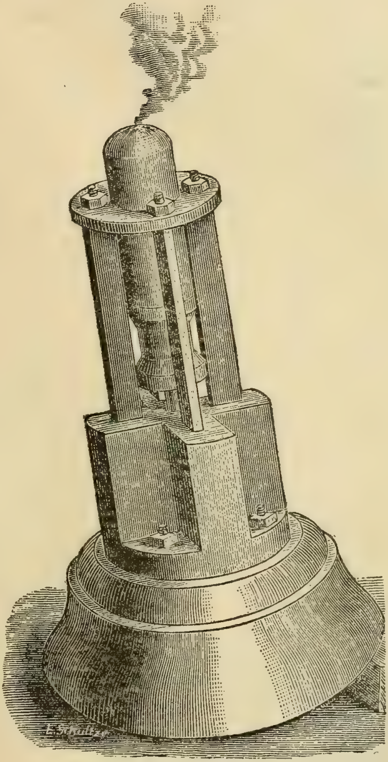


FIG. 1.—Pressure Gauge.

The piston (Fig. 2), which is the piece resting on the plug of lead, is a cylinder of tempered steel, four inches in diameter and five inches in length. It is turned away at the sides to lighten it as much as possible. It moves freely between the guides. In the top is a parabolic-shaped cavity to hold the charge of powder. The weight of the piston is twelve and one-quarter pounds.

The shot (Fig. 3), made of tempered steel, is four inches in diameter and 10 inches in length, weighing thirty-four and a half pounds. It is bored through its axis to receive a capped fuse.

To operate the instrument, a plug of lead is placed upon the steel plate within the guides. The piston is put down gently upon it, and the charge of powder placed in the cavity. The shot is next lowered gently upon the piston, and the capped fuse pushed down through the hole in the shot. The fuse being lighted, when

the fire reaches the cap the charge is exploded, throwing out the shot and compressing the lead plug. The accuracy of the test is based upon the assumption that the lead plugs shall be of uniform density and homogeneous structure. The form of plug adopted was a cylinder, one inch in diameter, and one inch in length (Fig. 4).

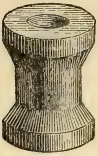


FIG. 2.—Piston of Pressure Gauge.

In regard to the kind of plug, my choice lay between plugs cast in molds, and plugs cut from a solid bar, which could be obtained of the desired dimensions in the factories.

This lead bar, though not made of perfectly pure lead, is manufactured from large masses of metal, is very dense, and can be obtained in lengths of 50 feet. It seemed to me that the desired uniformity would be more likely to obtain in this product than in plugs cast, one at a time, from small masses of metal. Having prepared plugs of both kinds, the next point was to test their relative merits for my purpose. The nature of this test was fixed by an additional and independent consideration. It should be borne in mind that while being compressed by the explosion in the pressure gauge, the density of the plug as well as the lead surface opposed to the piston continually increases. It is plain from this that the amount of compression shown by the plug is not a direct measure of the strength of the powder. For illustration: if one powder, exploded in the pressure gauge, compresses a plug $\frac{250}{1000}$ of an inch, and another powder compresses a plug $\frac{500}{1000}$ of an inch, the latter powder would be twice as strong as the former if the compressions were direct measures of relative strengths. But in fact the latter powder is more than twice as strong. The problem was, how much. As a practical measure of the strength, I assumed it proportional to the *work* performed in reducing the height of the lead plug. To get an expression for the work, it was only necessary to find the number of foot-pounds required to produce the different amounts of compression. Acting upon this reasoning, an apparatus was built as shown in Fig. 5.

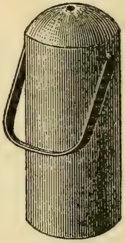


FIG. 3.—Shot of Pressure Gauge.

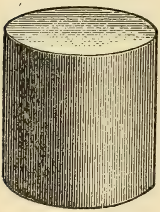


FIG. 4.—Form of Lead Plug used in Pressure Gauge, Full Size.

It consisted of three boards, so connected as to form a slide sixteen feet high, in which a weight (the shot of the pressure gauge) could fall freely. One of the boards was graduated into feet and half feet. The horizontal board at the bottom, upon which the others were nailed, rested on a heavy post set deep in the ground. A round tenon formed on the top of the post projected through a hole in the board. On the top of this tenon, turned bottom upwards, was placed the piston of the pressure gauge. This served as the anvil, and on it the plugs were placed. The fuse-hole of the shot was plugged with a large wire, which projected through the top and gave a hold for a simple form of clutch, by means of which and a light rope passing over a pulley at the top of the structure, the shot was hoisted to any desired height. The clutch was released by hand from the steps of a ladder.

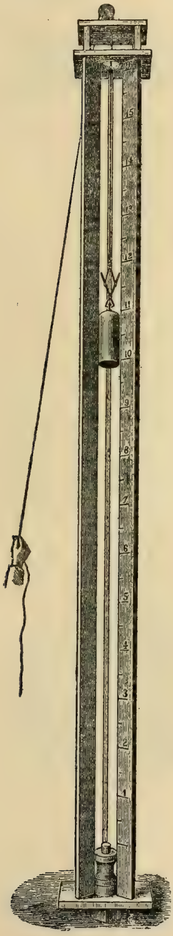


FIG. 5.—Foot-pounds Machine

My first work with this apparatus was to test the uniformity of both kinds of plugs. In selecting the cast plugs for test, they were carefully weighed, and all above or below a certain standard, as well as those showing any signs of flaws or other defects, were rejected. The first half-dozen blows upon the cast plugs showed such anomalous results that I rejected the whole batch, and molded a new lot, hoping by varying the method to obtain more homogeneous castings. The experiments with these, however, were far from satisfactory.

Turning next to drawn plugs, I had the satisfaction of finding them remarkably uniform. The plugs were carefully measured before compression and again after compression, by taking the average of several measurements. The difference between the original length and the reduced length gave the compression caused by the blow of the shot in falling.

The instrument used in measuring the plugs is the micrometer calipers, manufactured by Brown & Sharp (shown in the drawing Fig. 6).

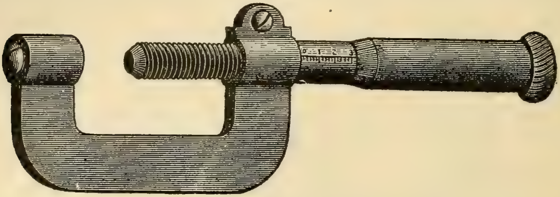


FIG. 6.—Micrometer Calipers for measuring Lead Plugs.

It is exceedingly accurate and convenient, and reads to the thousandth part of an inch, and even this space can be readily divided. The more uniform structure of the drawn plugs as compared with the cast is apparent in the different appearances of the two after reduction in the pressure gauge or in the foot-pounds machine. The drawings (Figs. 7 and 8) show this better than description. Having adopted the drawn plugs, I proceeded to construct a table for converting the compressions of the drawn plugs into foot-pounds, or actual measures of the strength of powder. This was simply and expeditiously done by making several series of experiments in dropping the shot from various heights, beginning with a half foot and going up a half a foot at a time to about sixteen feet. An average of all the compressions at a given height was assumed as correct. The height multiplied by the weight of the shot gave the foot-pounds corresponding to that particular compression.

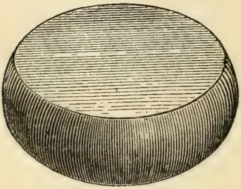


FIG. 7.—Drawn Lead Plug after compression.

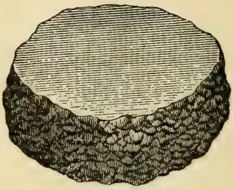


FIG. 8.—Cast Lead Plug after compression.

To more graphically represent the relations between the plug compressions and foot-pounds, as well as for convenience in my work, I constructed a diagram, using the compressions as the ordinates, and the foot-pounds as the abscissas of a curve.

The extreme co-ordinates were fixed by nitro-glycerin.

This diagram, 21 x 14 inches, has been relied upon for converting plug compressions into foot-pounds, or units of strength. My standard charge for the pressure gauge is 24 grains."

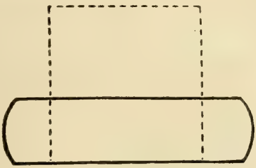


FIG. 9.—Section of Plug showing reduction in Pressure Gauge.

The diagram referred to, together with the original record of the experiments with the foot-pounds apparatus, was destroyed by fire in my laboratory several years ago. However, the curve will be found very accurately reproduced in the dotted line on Plate I.

When Lieutenant Walke was preparing for his experiments he wrote to me for a copy of the diagram or table from which it could be constructed. At that particular time I could not furnish the required data. Since then I have got possession of my note books in which I had recorded several hundred plug compressions by different explosives (covering the whole range of the curve) with the corresponding foot-pounds taken from the diagram. These have enabled me to replot the curve very accurately. Of course there were some mistakes among these co-ordinates, but the error was generally so large as to leave no doubt about the propriety of rejecting it in constructing the curve.

In using the crusher gauge for testing high explosives I have assumed that a given compression of a lead plug denotes exactly the same amount of work, whether the compression be caused by a falling weight or by an explosive—not a very violent assumption, and yet I doubt if it is strictly true. However, we are not prepared to discuss this point just now.

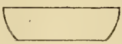
Comparing great things with small, it is a satisfaction to know that General Abbot, working independently upon the same subject, adopted the same material—lead—to record the action of his explosives, and determined the foot-pounds corresponding to plug compressions in substantially the same way. He used the blow of a swinging pendulum for this purpose. For his unit, however, he adopted *intensity of action*, which he defines as the mean pressure, to obtain which he divides the foot-pounds representing the kinetic energy or work of the pendulum hammer by the path described by

the point of application of the force in its line of direction ; that is, he divides the work expressed in foot-pounds by the plug compressions expressed in feet to obtain the mean pressure in pounds. He used lead plugs of different sizes, which gave different paths for the same work, and, consequently, different mean pressures for the same force. To overcome this difficulty, he decided to translate his energies into mean pressures by adopting the indentation of Rodman's pointed indenting tool into discs of copper as the uniform path to be used (see page 26 of his "Report on Submarine Mines").

General Abbot's problem was much more difficult and intricate, in that the blows of his explosives were transmitted through water, and the law of variation in energy and intensity with weight of the charge, depth of submergence, distance and angle of direction, had to be determined, while a host of minor conditions had to be dealt with and disposed of.

His methods, in my opinion, are beyond criticism. Thoroughness in practical experimentation is supplemented by equal thoroughness in analysis. No labor is shirked, no guessing is indulged in, no short cuts taken to doubtful conclusions. The task imposed was herculean ; its accomplishment has a singular completeness and definition. The Report is a model of careful and accurate work in a new field.

Laws of Compression of Cylindrical Lead Plugs.

We return to a consideration of the curve on Plate I (see broken line), which gives the relation between plug compression and the corresponding work in foot-pounds for a certain kind of cylindrical one-inch lead plugs. This curve was constructed from experiments with the foot-pounds or falling weight machine. The plugs compressed in this way were remarkably uniform in appearance. Figure 7 (page 512) gives a good general idea of their shape. Now, in examining a variety of plugs *compressed by explosives*, I have made certain general observations, as follows : For moderate compressions the plug remains a true cylinder ; this form holds good up to a compression of about .200″. For higher compressions, say up to .400″, the plug departs more and more from this form and becomes barrel-shaped. At still higher compressions it becomes tub-shaped —large end up—sides slightly rounded, thus  ; at .600″ this form is quite marked.

The retention of the cylindrical form for even moderate compres-

sions is rather remarkable, and shows that the flow of the metal is equal in all the horizontal layers.*

It occurred to me that the change of form might be due to or, at least, accompanied by a corresponding change of density, and that the density for small compressions might be sensibly uniform. I therefore weighed in air and water five plugs. One was of original full length as cut from the bar, the others had been subjected to various degrees of compression up to .670″. The first was a true cylinder, one inch in diameter, the next was a cylinder of greater diameter, the next two were barrel-shaped, and the last was a flat disc 1¾ inches in diameter across the top, with a decided tub shape.

The original lengths varied from .983″ to .992″. The results were as follows:

		Wt. in air. Grammes.	Wt. in water. Grammes.	Sp. gravity.
1.	Original plug,	144.45	131.76	11.383
2.	.159″ compression,	143.78	131.15	11.384
3.	.305″ "	144.95	132.22	11.386
4.	.409″ "	145.11	132.37	11.390
5.	.670″ "	145.09	132.37	11.406

Although the scales were not delicate enough for very fine work, a law of change in density is clearly shown, and, so far as the evidence goes, it disproves my assumption that the density remains constant for small compressions. I was led, however, by this erroneous assumption into the following speculations, part of which are certainly more curious than useful, but may, nevertheless, be of interest. If we assume that the density remains the same, and that the plug retains the cylindrical form throughout (which is not very far from being true), the relation between compression and work can be readily deduced, for the resistance will then be directly as the area of the surface pressed, and the volume being constant this area will bear a simple relation to the compression.

Let $y =$ compression.

$L =$ original length of the plug.

$L - y = z =$ reduced length of the plug.

$A =$ area of top of the plug.

* The same remark applies to the small copper cylinders used by ordnance experts for taking powder pressures in guns. Those that I have seen preserve the cylindrical form very accurately for moderate compressions, either by powder or by a falling weight.

$V =$ volume—constant.
$K =$ a constant—the resistance per unit of area.
$R =$ variable resistance.
$x =$ work of compression.

Then $R = A\,K$, and since $Az = V$,

$$R = \frac{KV}{z} \text{ or } Rz = KV,$$

which is the equation of a hyperbola referred to its center and asymptotes.

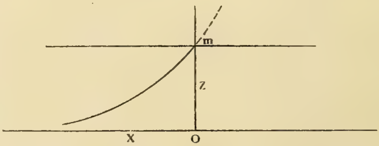
For simplicity we assume the asymptotes to be at right angles to each other. Then since

$$x = \int Rdz = \int KV \frac{dz}{z},$$

we have $x = KV \log z + C$, x being the area included between one branch of the hyperbola and the asymptotes.

If we call L—the original length of the plug—unity and make this the ordinate of the vertex from which to estimate the area, we have $Z = 1$, $KV = 1$, $C = 0$; whence $x =$ Napierian log z. That is, the work of compression is the Napierian logarithm of the reduced length of the plug when the original length and the resistance at the beginning are each considered unity. z being less than unity, x will be negative, and we consider only that part of the logarithmic curve to the left of the axis of z, or axis of numbers.

The curve, like all logarithmic curves, crosses the axis of numbers at the distance unity from the origin, and, since the modulus is unity, it crosses at an angle of 45°—the modulus being equal to the subtangent on the axis of logarithms. The axis of x is an asymptote to the curve.



To express the equation of the curve in terms of y, we transfer the origin to the point m, which gives $x =$ Napierian log $(1 - y)$.

This value for the work is expressed in terms of the length of the plug and of the primary resistance, each taken as unity, and is not directly comparable with *foot-pounds*.

To make such a comparison we must assign a modulus to the system of logarithms which is perfectly legitimate on other grounds, since we could have referred the original equation of the hyperbola $Rz = KV$ to asymptotes which were oblique to each other, in which case the sine of the angle included by them would have become the modulus of the system.

In selecting a modulus we have a small latitude. Properly we should take a modulus which would cause the logarithmic curve to make the same angle with the axis of y or z, as does the actual curve constructed from experimental data. Determining this angle would depend upon the accuracy of the construction. We can arrive at nearly the same thing by assuming the curves coincident for small values of y.

Following is a table of values of x (corresponding to the assumed values of y) deduced from the equation, $x = \log (1-y)$ and also from $x = .234 \log (1-y)$, the minus sign of x being omitted.

y = compression.	x = work.	
	$m = 1$	$m = .234$
$y = .050$	$x = .051$	$x = .012$
$y = .100$	$x = .105$	$x = .025$
$y = .200$	$x = .223$	$x = .052$
$y = .300$	$x = .356$	$x = .083$
$y = .400$	$x = .511$	$x = .120$
$y = .500$	$x = .693$	$x = .162$
$y = .600$	$x = .916$	$x = .214$
$y = .700$	$x = 1.204$	$x = .282$

In plotting the logarithmic curve corresponding to the modulus .234 for comparison with the experimental curve, since y expressed in thousandths of an inch is taken as a whole number, the values of x must be multiplied by 1000 also, or the numbers in the last column above taken as whole numbers. The curve will be found on Plate I.

For plugs of one inch diameter we see that there is no close agreement between the logarithmic curve and the actual. But the former was deduced under the assumption that the density remained the same and that the plug retained the cylindrical form, neither of which propositions is true. It will hereafter be shown that for plugs of smaller diameter the agreement of the logarithmic curve with facts is closer, but we will now try to deduce a form of equation which is

more flexible than the logarithmic and better adapted to represent the relation between work and compression. It is true we cannot apply the same rigid course of reasoning in deducing it, but the result seems to be reliable for practical use.

As to the general form of the equation: first, it must be such that the curve passes through the origin—that is, it has no absolute term; second, it must be concave towards the axis of x $\left(\frac{dy}{dx}\right.$ a decreasing function of $\left.x\right)$; third, L being the original length of the plug, a line parallel to the axis of x at distance L must be an asymptote to the curve.

The simplest equation to fulfil these conditions that has occurred to me is

$$x = \frac{y}{L - y} \text{ or } y = \frac{Lx}{1 + x};$$

in fact, it is too simple for our purpose. It is probable that y needs both a coefficient and an exponent to represent the curve. Giving y a coefficient B, we have

$$x = \frac{By}{L - y}, \text{ in which } L = 1000.$$

Testing this by applying it to the dotted curve of Plate I, we determine the value of B from some of the co-ordinates taken from the curve, as follows:

Foot-pounds.	Comp. $\frac{1}{1000}$ inch.	
$x = 30$	$y = 100$	$B = 270$
$x = 80$	$y = 200$	$B = 320$
$x = 145$	$y = 300$	$B = 338$
$x = 233$	$y = 400$	$B = 349$
$x = 356$	$y = 500$	$B = 356$
$x = 430$	$y = 550$	$B = 352$
$x = 530$	$y = 600$	$B = 353$

The only glaring anomaly in this table is $B = 356$, which, it is plain to see, results from the flattening of the curve about this point. We conclude, however, that B is not a constant, as it should be if the equation were adequate, and that y needs an exponent greater than unity. The equation then becomes

$$x = \frac{By^a}{L - y};$$

L in this particular case being 1000.

I determined a number of values of a and B by using the values of x and y, given above, taking them in sets of two. This process gave values for B ranging from 160 to 210, and corresponding values for a from 1.2 to 1.05. Each set of these, applied to the equation above, determined a curve agreeing more or less closely with the dotted one and coinciding with it in at least two points. I finally selected as the best values those in the following equation:

$$x = \frac{190y^{1.1}}{1000 - y},$$

and the full curve in the plate is constructed from this.

The following short table of co-ordinates gives a comparison of the values of x as taken from the dotted curve (or rather from one drawn previously on a larger scale), and the values of x calculated to the nearest whole number from the above equation:

Compression in $\frac{1}{1000}$ inch. y.	Foot-pounds, dotted curve. x.	Foot-pounds, computed. x.
50	12	15
100	30	33
200	80	81
300	145	144
400	233	231
500	356	354
600	530	540

By means of this table the plotting of both curves on Plate I can be checked. The plotting is not perfectly accurate. Except at the extremities the agreement of the two curves should be closer than shown by the plotting.

We can also deduce a general equation of the form

$$x = \frac{By^a}{L - y};$$

in this rather clumsy way: If in the equation

$$R = \frac{KV}{z} = \frac{KV}{L - y},$$

we assume R to be the *mean* resistance corresponding to the compression y, K and V having suitable values, we have the following simple expression for the work,

$$x = \frac{KVy}{L - y}.$$

But K and V are no longer constants. V, the volume, diminishes slightly as y increases. Its particular value in this equation corresponds to some fractional part of y. K, the resistance on the unit of area, increases as y increases, but its value also corresponds to some fractional part of y. The product KV is, therefore, a function of y, probably of the form $CKVy^b$, in which C is a constant, K and V have their *primitive values*, and b is a fractional *exponent less than unity*. Substituting this for KV in the equation above, omitting C, and placing $1 + b = a$ for a new exponent, we have

$$x = \frac{KVy^a}{L - y},$$

as our general equation for cylindrical lead plugs, in which

$x =$ work expressed in foot-pounds,
$y =$ compression expressed in $\frac{1}{1000}$ of an inch,
$L =$ original length of the plug expressed in $\frac{1}{1000}$ of an inch,
$V =$ original volume of the plug,
$K =$ constant depending on the nature of the lead,
$a =$ number between 1 and 2.

The only other recorded comparison of the compression of lead plugs with the work required to produce them, that I know of, is given in General Abbot's Report (page 22). His plugs were all made from a single lot of lead selected at the Rock Island Arsenal. They were made by casting and compressing in a mold, the surplus lead being allowed to escape through a small hole. Five sizes of plugs were used, $\frac{75}{100}$, $\frac{6}{10}$, $\frac{5}{10}$, $\frac{4}{10}$ and $\frac{3}{10}$ in diameter. The first three sizes were about 1 inch long, the $\frac{4}{10}$ was .8 inch long, and the $\frac{3}{10}$ was .6 inch long. The table of the compression of these with the corresponding foot-pounds by the pendulum hammer is given on page 22 of the Report. We have constructed the curves represented in this table on Plate II. In the construction the same linear value is given to one foot-pound as to $\frac{1}{1000}$ of an inch of compression.

In regard to the curves for the smaller leads, $\frac{3}{10} \times .6$, $\frac{4}{10} \times .8$ and $\frac{5}{10} \times 1$, it will be noticed that the curves have a certain parallelism. The $\frac{3}{10}$ and $\frac{4}{10}$ curves nearly coincide, which shows that shortening the plug compensates, in a measure, for increasing the diameter. This appears from our general equation for cylindrical plugs,

$$x = \frac{KVy^a}{L - y};$$

for since $V = LA$, A being the area of top of plug,

$$x = \frac{KALy^a}{L - y},$$

which shows that the work is directly proportional to the original area of cross section, and, since L is greater than y, x is a decreasing function of L; that is, the shorter plug requires more work for equal compressions.

But we also see from the same equation that for plugs of a given diameter or area A, since L enters both numerator and denominator, that *small variations* in the length will affect the work very slightly, which is some comfort to a man who cuts his plugs in a miter box.

Now, in regard to the curve for the $\frac{3}{10}$ lead, if we assume that it is represented by the equation

$$x = \frac{KVy}{L - y} \text{ or } x = \frac{By}{L - y},$$

in which the exponent of y has been omitted and L is equal to 601, and substitute the values of x and y given in General Abbot's table (omitting values of x less than unity), and compute the corresponding values of B, we have the following:

Foot-pounds.	Compression $\frac{1}{1000}$ inch.		
$x = 2.496$	$y = 90$	$B = 14.2$	
$x = 5.612$	$y = 160$	$B = 15.5$	
$x = 9.932$	$y = 232$	$B = 15.7$	Mean $B = 15.1$,
$x = 15.460$	$y = 300$	$B = 15.5$	
$x = 22.090$	$y = 357$	$B = 15.1$	
$x = 29.870$	$y = 404$	$B = 14.5$	

from which we see that B is very nearly constant, and the curve for the $\frac{3}{10}$ lead can be quite accurately represented by the equation

$$x = \frac{15y}{601 - y}.$$

If we treat the curve for the $\frac{4}{10}$ lead the same way and calculate the values of B for the same values of x (neglecting those below 10), we will find B to vary between 31.7 and 36.5; in other words, y in the equation of this curve needs a very small exponent. For the

$\frac{5}{10}$ and $\frac{6}{10}$ curves we find B to increase a little faster. For the $\frac{75}{100}$ lead, using the equation

$$x = \frac{By}{1006 - y},$$

we find the values of B to increase pretty steadily from

$$x = 9.9, \quad y = 75, \quad B = 123,$$

to

$$x = 165, \quad y = 500, \quad B = 166.$$

From this discussion we see that the value of a, the exponent of y, in the equation

$$x = \frac{By^a}{L - y},$$

increases with the diameter of the plug; that it is about unity for the $\frac{3}{10}$ plug, probably less than unity for smaller sizes, and is about 1.1 for one-inch plugs.

Moreover, if we construct a logarithmic curve for each of these leads (as I have done, though they are omitted in the plates) from the equation $x = \log (1 - y)$, taking the length of the plug as unity, and assuming a modulus which will make the logarithmic curve coincide with the real curve for small values of y, we find that the fault of the logarithmic curve is that it is too nearly straight, that it lies between the real curve and the axis of Y, but that it agrees better with the real curve for the smaller leads than the larger. The inference is that there would only be coincidence for a lead indefinitely small, and, since the logarithmic curve is deduced under the hypothesis that the density of the plug remains constant during compression, we conclude that the density during compression increases the more rapidly as the diameter of the plug is greater.

If we now consider the curves (Plate II) for the $\frac{5}{10}$, $\frac{6}{10}$, and $\frac{75}{100}$ leads, which were all one inch in length, we see that they have not the parallelism of the $\frac{3}{10}$, $\frac{4}{10}$, and $\frac{5}{10}$ curves, but though they diverge, they are regular and consistent one with another, the plugs showing more work for the same compression in proportion to their size. To see how exactly this proportion holds, we will assume that for a given compression the work is proportional to the area presented to the hammer or piston.

If the density remained the same, this area would be proportional to the original area. Moreover, if in two plugs of different diameters but the same length the law of change in the density were the same—that is, the densities of the two were equal for equal compressions—the *works* would still be related as the original areas. If the leads are of equal hardness, this is implied in one general equation,

$$x = \frac{KALy^a}{L-y},$$

provided the value of a is independent of the diameter. Now, if we consider two plugs, such as the $\frac{6}{10}$ and $\frac{75}{100}$, the law of change in the density would not be exactly the same. If we reflect that the density increases because the flow of the metal is retarded, we see that the density must increase more rapidly in the larger plug, and this for a given compression should show more work than its relative area calls for, a conclusion we had already arrived at in another way.

To illustrate this I have attempted to reduce the curve for the $\frac{5}{10}$ lead to that for a hypothetical $\frac{6}{10}$ lead by multiplying its values of x (foot-pounds) by 1.44, the ratio between the original sectional areas; also the $\frac{6}{10}$ curve to a hypothetical $\frac{75}{100}$, by multiplying x by 1.56.

It will be seen that the agreement of the reduced curve in both cases with the original curve is very close for low compressions, but there is a difference for higher compressions, the real plug showing a little more work for the same compression. The divergence to the right of the curve for the real and larger plug is represented in one equation by a slight change in the exponent a, which, as we saw before, increases slightly with the diameter.

For the sake of comparison, I have plotted on Plate I the curve for General Abbot's $\frac{75}{100}$ lead, and deduced from it the curve for a hypothetical one-inch plug by multiplying the values of x by 1.78. This hypothetical one-inch plug differs from a real one-inch plug made from the Abbot lead in the same way that the hypothetical $\frac{75}{100}$ varied from the real plug of that size. If we had chosen to assume that the same law held, we could have drawn the curve for the real plug pretty accurately, but the hypothetical one answers our purpose. The conclusion is that the Abbot lead was softer than

mine, as it shows less work for the same compression. It was probably a very pure lead from one of the Galena ores, which is especially noted for purity. Mine was Selby lead, and contained a small percentage of hardening impurities, which did not affect, however, its fitness for the purpose. The superintendent of the Selby Smelting Works informed me that the impurities were small quantities of antimony and zinc. A San Fráncisco chemist of repute once told me that it carried also traces of silver.

Since the above was written I have tested some *pure* lead plugs, cut like the first from one-inch lead bar. Mr. Alfred Rupp, of the Selby Works, was kind enough to have the lead analyzed for me. He writes that it contains only *traces* of zinc and antimony.

I determined a short curve for these plugs by making a series of experiments with the foot-pounds machine. The curve, which is remarkably uniform, is plotted near the hypothetical curve for Abbot one-inch lead, and agrees with it very closely. It is also plotted in Plate II. By reasoning on the curves it is easy to see that this lead agrees very nearly in properties with the Abbot lead. It was probably a little softer than the Abbot.

We can sum up this part of the subject by saying that the relation between work and the compression of cylindrical lead plugs by a falling weight may be approximately represented by the general equation

$$x = \frac{KVy^a}{L - y},$$

in which K is a constant depending upon the nature of the lead, V the original volume, L the original length of the plug, and a a small exponent which increases slightly with the diameter.

It will be shown later that the *form* of this equation is incorrect, but the co-ordinates given by it are quite accurate, except near the origin.

The Anomalous Sub-Aqueous Action of Nitro-Glycerin.

Returning to consider General Abbot's work, we note his table of the relative intensities of action of various high explosives, which has been quoted so often that it has become classical. It is here given for a few of the most prominent explosives only. I have

added the relative energies calculated from the intensities by General Abbot's rule.

Explosive.	Action under water.	
	Relative intensity.	Relative energy.
Dynamite,	100	100
Explosive Gelatine ('81),	117	126
" " ('84),	142	169
Forcite,	133	153
Dualin,	111	117
Hercules No. 1,	106	109
Gun-cotton,	87	81
Mica Powder No. 1,	83	76
Nitro-glycerin,	81	73
Mica Powder No. 2,	62	49

It must be noted that these relative intensities are taken horizontally. General Abbot also gives (p. 110) the relative intensities taken vertically upward and downward, dynamite being again taken as the standard. Lieut.-Col. J. P. Farley, of the Ordnance Department, in a recent paper, "Compilation of Facts Relating to High Explosives," published in the Journal of the Military Service Institute, November, 1891, falls into a serious error in commenting upon General Abbot's work in the following sentence: "It has been shown experimentally that the forces developed by a subaqueous explosion indicate that the normal line of maximum intensity will be directed downward," whereas the maximum effect is upward. Colonel Farley was probably misled by the table on page 110, in which dynamite is taken as 100 in all three directions, the numbers in each column being relative only to themselves, but it is shown by the context and pictorially by Plate XIV that its action is fifty per cent. greater upwards than downwards. This error, which is probably nothing more than the slip of a pen on the part of Colonel Farley, is mischievous, because it tends to confirm a foolish notion firmly rooted in the minds of miners and other practical men that high explosives have some special property of acting downwards. This table is very instructive, as it shows a greater relative efficiency downward for the more intense acting explosives. To illustrate, dualin, which gives 111 compared with dynamite horizontally, gives 116 compared with it downward (really 68 compared with its own upward action, and 80 with its own horizontal action

taken as 100). Hercules gives 106 horizontally and 109 downwards. Explosive gelatine (1881) 117 horizontally and 125 downwards. (The downward action of dynamite is 64 compared with its upward action, and 77 compared with its horizontal action.) General Abbot appropriately remarks: "The greater the resistance to be overcome the more distinctly marked are the differences between the intensity of action of the several explosive agents. In other words, the most severe test of their relative power under water is their action vertically downward. As the work required of them in submarine mining, however, varies from the horizontal plane upward, their relative horizontal action appears to be the true criterion."

It is a remarkable fact that nitro-glycerin should stand so low in this scale—81 compared with 100 for dynamite. Its action downward shows a still more startling difference—71 against 100 for dynamite.

This anomal is certainly very surprising, as it is generally acknowledged that nitro-glycerin in rock blasting does at least $\frac{4}{3}$ as much work under similar conditions of confinement as dynamite, or in other words, gives the result naturally expected of it. Dynamite consists of 75 per cent. nitro-glycerin and 25 per cent. of an inert absorbent, kieselgühr, which cannot be expected to add to the strength of the explosive, and yet, according to General Abbot, in sub-aqueous explosion the intensity of action of nitro-glycerin is only about $\frac{8}{10}$ that of dynamite or $\frac{6}{10}$ of what we would naturally expect.* "A part seems to be greater than the whole," to adopt an expression which the late impetuous Geo. M. Mowbray was wont to use in confounding the rivals of his tri-nitro-glycerin, and yet no one who reads General Abbot's Report can doubt for a moment that his rating of nitro-glycerin is a "fact." We may differ in interpreting his results, but the results must be accepted.

This anomaly receives an incidental discussion in a paper entitled "Explosives and Ordnance Material," by Mr. S. A. Emmens, published in the Proceedings of the U. S. Naval Institute, No. 59, 1891. The paper is very entertaining, and furnishes much food for thought. Mr. Emmens gives General Abbot's theory as summarized by Pro-

*This is only rough reasoning. The real discrepancy is larger. General Abbot uses mean intensity of action as a measure. If he had used work—quantity of action—the figure for nitro-glycerin would have been about 73, not quite 55 per cent. of normal—133.

fessor Munroe, which (p. 110, "Submarine Mines,") is thus given by General Abbot himself: "Dynamite No. 1 is simply nitro-glycerin granulated. With gunpowder granulation promotes intensity of action by opening passages for the initial flame to permeate the mass and thus accelerate the formation of the gases. Were this the true explanation of the phenomenon in question, a similar relative strength between the two explosives would also be shown in rock blasting, which is contrary to observation, as nitro-glycerin in hard rock is admitted to be by far the stronger of the two. Let us suppose, on the other hand, that granulating nitro-glycerin by absorbing it in kieselgühr has precisely the contrary effect, *i. e.* that the particles of silica slightly retard chemical action, as is not unlikely, since in detonation the reactions may occur within the molecules. This idea appears to me to supply the required explanation; for the resistance opposed by water, being of a slightly yielding character, may exact more time than is afforded by nitro-glycerin pure and simple. I regard this as the most plausible explanation of a fact which, although novel, is so well established by my experiments that its correctness can hardly be questioned."

Mr. Emmens takes issue with General Abbot, and objects to the nitro-glycerin in dynamite being considered granulated, because "careful inspection shows no interruption of liquid continuity in the nitro-glycerin constituent of dynamite." One might interpret this sentence to mean that the dynamite consists of a continuous liquid with the solid suspended in it. The dynamite would then be almost incompressible and as sensitive as the liquid itself, but no such meaning was intended. I examined with a powerful microscope two varieties of dynamite—one, Nobel's, made in Scotland; the other made by myself from German kieselgühr. Under the microscope, although there is a marked granulation, the liquid appears to predominate much more than to the naked eye. The appearance by transmitted light is something like a pile of dirty snowballs. In the sense that every particle of the liquid at certain points touches other particles, or, in other words, that there is no particle completely isolated from its fellows, I think Mr. Emmens is right.

He then makes this point: "Moreover, the reference made by Professor Munroe to certain dynamites 'which are made so as to explode with exceeding rapidity, and which fall very low in the scale,' is not borne out by the best-known of such quick-action

dynamites, viz., Mowbray's mica powder. No. 1 grade of this powder, containing only 52 per cent. of nitro-glycerin, gave a force of 102, as compared with 100 for pure nitro-glycerin."

Of course Professor Munroe's comparison, based on General Abbot's views, was with dynamite. Nitro-glycerin itself is low in the scale.

Still Mr. Emmens' point is well taken. If quickness were a cause of failure, why should quick mica powder give 83 compared with 100 for dynamite, when it contained only $\frac{70}{100}$ as much explosive matter? A part of this discrepancy disappears if we compare the energies instead of intensities—100 : 76 instead of 100 : 83. Another answer to the riddle is that there is no *proof* that mica powder was specially quick, except the dictum of Mowbray, which General Abbot gives without endorsement, but to which he attaches too much importance. It must be remembered that Mowbray was sued for infringement of the dynamite patent by the Atlantic Giant Powder Company, and he was cudgelling his brain for some point upon which to hang a specific difference. Mica powder, in the opinion of fair-minded, practical men, was a bold infringement of Nobel's invention; but Mowbray made a gallant fight, which consisted of unflinching assertions based upon *à priori* reasoning.

Mr. Emmens solves the problem by his "Ballistic Theory of Explosives," which is based upon the kinetic theory of gases, according to which the pressure of a gas upon the walls of its containing vessel is caused by impacts of the gaseous molecules upon the walls. The *vis viva*, or energy, of the molecules has two factors —mass and velocity. "The character of the blow as regards the effect produced upon the body struck must be different in the cases of two projectiles, one of which (say a molecule of carbonic anhydride) weighs 22 times as much as the other (say a molecule of hydrogen), even though the energies of the two blows be equal." He then illustrates his theory by a proximate calculation of the factors mass and velocity in the case of nitro-glycerin and dynamite. We have no exception to take in the case of nitro-glycerin. He first calculates the volume of gases produced by 1000 grammes of nitro-glycerin (reduced to 0° C. and 760 m.m. of mercury), then the temperature of the gases, then the volume due to this temperature, and finds this quantity 18,738.7 liters. He then proceeds as follows: "But if the nitro-glycerin be confined in a shell, for

example, then 18,738.7 liters would be compressed within the space of $\frac{1}{1.6}$ liters, and therefore would press upon the walls of the shell with a force equal to $18{,}738.7 \times \frac{1.6}{1} = 29{,}981.9$ atmospheres. The mass being 1000 grammes, the velocity factor may be taken as $\frac{29981.9}{1000} = 29.9819$." I think no one can take exception to this reasoning, but when it comes to dynamite the case is different. Having calculated the elements as before, he finds the expanded volume of the gases 10,861 liters and "the silica expanded 20.05 cubic centimeters in excess of its original volume. But if the explosion took place in a close vessel, the space available for the gases would be $\frac{1}{1.6} \times \frac{3}{4} - 20.05 = .4487$ liters, and the pressure would therefore be $\frac{10861}{.4487} = 24{,}205.5$ atmospheres. The mass factor of this pressure is 750 (as the dynamite gases have but .75 of the weight of the gases produced by 1000 grammes of nitro-glycerin) and the velocity factor is $\frac{24205.5}{750} = 32.27$." I hold that this calculation is open to such serious criticism as to impair the conclusion in its general application to dynamite. It is plain to see that this result is a question of density of loading.

For nitro-glycerin this is properly assumed as 1.6, and the 1000 grammes of products occupy $\frac{1}{1.6} \times 1000 = .625$ liters, while for dynamite, as the space available for the gases is only .4487 liters—if we take into account the loss of space by expansion of the silica—the original space allowed was .46875 liters, corresponding to a density of 2.13 for the dynamite. The density of the dynamite compacted into cartridges is 1.4. It appears, therefore, that Mr. Emmens' calculation applies only to a theoretical case which cannot be realized in its essential conditions.

As to the effect of density of loading in General Abbot's experiments, the latter show that within wide limits his results are independent of it. If it be contended that Mr. Emmens' reasoning is strictly theoretical and based upon ideal conditions, the answer is that it is offered as the explanation of a practical problem—the anomalous action of nitro-glycerin and dynamite in sub-aqueous explosion. General Abbot has shown that a void, as he calls it in his table, of three times the volume of the charge does not affect the registered energies of dynamite.

If Mr. Emmens is right, the presence of the inert matter in dynamite gives additional velocity to the molecules of the gases, whereas one would naturally think that it would impede their motion slightly.

This latter idea is borne out by tests with the crusher gauge, made by Drinker himself. (See "Tunneling, Explosive Compounds and Rock Drills," pages 78 and 79.)

"The second trial was to test whether in ordinary No. 1 dynamite (or giant powder), composed of 75 per cent. of nitro-glycerin and 25 per cent. infusorial earth, there was any appreciable loss of power by the absorption of the nitro-glycerin in the infusorial earth.

"(*a*) Charge 1.5 grammes No. 1 dynamite.

Mean height of leads before firing,	.932″
" " " after "	.194″
compression	.738″

"Next the amount of pure nitro-glycerin combined in 1.5 grammes No. 1 dynamite was taken.

"(*b*) Charge 75 per cent. of 1.5 grammes=1.125 grammes nitro-glycerin.

Mean height of leads before firing,	.933″
" " " after "	.180″
compression	.753″

"Therefore

"(*c*) Compression exerted by No. 1 dynamite,	.738″
" " " nitro-glycerin alone,	.753″
In favor of nitro-glycerin alone,	.015″

"This difference is very small; still it would appear sufficient to indicate, if not a *practical*, still a positive and *appreciable* diminution of the effective power of the nitro-glycerin by the absorbent." This small difference, .015″, is the less insignificant on account of the conical shape of Drinker's plugs. The comparison, it must be noted, is between a certain weight of dynamite and three-fourths of the same weight of nitro-glycerin.

I have repeated Drinker's experiment several times, and have also varied it slightly by taking the weight of the nitro-glycerin as a fixed quantity. I first fired 24 grains of nitro-glycerin and noted the compression. To a second charge of 24 grains, weighed and placed in the cavity of piston, I added 8 grains of kieselgühr,

which I mixed carefully with the point of a knife. In every case I have confirmed Drinker's conclusions.*

To resume, Mr. Emmens finds that the ratio $\frac{29.98}{32.27}$ between the velocity factors which he has calculated for nitro-glycerin and dynamite, agrees fairly well with the intensity ratio observed in the course of General Abbot's experiments, certain allowances being made. We have shown, we think, that no credence is to be given to the figure 32.27 as applied to dynamite.

He goes on to compare the figures with those of Lieutenant Walke's recent experiments, but in this he falls into a grave error. Lieutenant Walke expressly explains that his compressions are not to be assumed as direct measures of either energy or intensity, and in arranging his table he is careful to use the expression "*order* of strength." Nevertheless Mr. Emmens treats the figures representing the order of strengths (which are directly proportional to the compressions, taking the compression for nitro-glycerin as 100) as energy measures, so that his reasoning on them is vitiated. There is a hopeless confusion in all this of energy or quantity of action with intensity of action.

But if Mr. Emmens' theory is wrong, how is the anomaly, which he aptly calls the "Abbot effect," to be explained?

If we admit that the shock of nitro-glycerin is greater than the shock of dynamite, which is a fair general assumption, and yet we find that the effect of the shock transmitted through water is the greater for dynamite, one of two things must be true: either there was

* In the same series of experiments I tried the effect of a variety of substances by adding 8 grains of each to the regular charge of nitro-glycerin—an interesting investigation, the results of which were briefly as follows: Nearly all the substances tried showed an *increase* of compression, except inert mineral *absorbents*. The better the absorbent the greater the falling off in the compression. Clean, sharp sand is neutral, or nearly so. Overburnt charcoal shows a slight increase; underburnt charcoal has greater effect; bituminous coal still greater. Water shows a very great increase, due partly to tamping action, as it floats on the top of the nitro-glycerin; but even when divided up by using 4 grains of wood pulp and 4 grains water, it still shows a considerable effect, nearly equal to the wood pulp alone. The substances giving the greatest effect are wood pulp, fine sawdust or other vegetable fibre, pulverized sugars, starches, bituminous coals, anhydrous oxalic acid, paraffin wax, petroleum oils, etc.

The conclusion I arrived at was that the increase in some cases was partly due to the oxidizing effect of the surplus oxygen in the nitro-glycerin (as in the case of the charcoal), but generally and chiefly to the production of additional amounts of gas.

In the case of the sand, the union is not close enough to have any effect.

In the case of inert absorbents like kieselgühr, the heat and motion are shared with the solid particles without compensation.

In the case of organic absorbents and other active substances, the heat and motion are shared, but this is more than compensated for by the production of additional gas. The subject, however, is too large to be fully discussed in a foot-note.

something in the conditions to vitiate our premises in regard to the relative intensities of the initial shocks, or the whole shock has not been *transmitted* in the case of nitro-glycerin, part of the energy being lost in the medium. The second horn of the dilemma is the one which General Abbot accepts, in saying that the "resistance of water, being slightly yielding, may exact more time than is afforded by nitro-glycerin." But we will consider the other first. The only condition which could vitiate our premises is a loss of part of the nitro-glycerin, that is, the whole charge is not exploded.

This view is more worthy of consideration than appears at first blush. Perhaps the liquid condition of the explosive (for nitro-glycerin is singular in being the greatest anomaly in the table as well as the only liquid), in presenting an almost incompressible medium for the transmission of pressure to the containing case, may offer an explanation. Is it possible that the initial shock, set up by the detonator, could burst the case (usually an open tin can or glass bottle) before the whole body of the liquid charge exploded? This gives rise to a number of interesting questions. Is there an *explosive* wave independent of the *pressure* wave? If so, has one greater velocity than the other? If we can rely upon certain English experiments, both questions may be answered, I think, in the affirmative. In this connection we cite the attempts of Captain Nobel, in England, to measure the velocity of detonation of dynamite, gun-cotton and nitro-glycerin. I have no record at hand except a scant memorandum, but if my recollection does not play me false he found the velocity for dry gun-cotton to be about 17,000 to 18,000 feet a second, the velocity for dynamite about the same, and the velocity for wet gun-cotton 18,000 to 21,000 feet a second. These explosives were fired in long paper cylinders. For liquid nitro-glycerin in V-shaped wooden troughs he found the velocity about 5000 feet a second.

The velocity of the pressure wave is simply the velocity of sound. Liquid nitro-glycerin would transmit sound much more rapidly than a heterogeneous, inelastic mixture like dynamite. We may then say that nitro-glycerin transmits pressure to the case very rapidly, while the detonation proceeds slowly, and dynamite transmits pressure very slowly while the detonation proceeds rapidly.

Contrary to general belief, the explosion of nitro-glycerin or even dynamite, though rapid, is by no means instantaneous. If a cart-

ridge of dynamite is placed on end on an iron plate and fired with a detonator at the top end, the effect is greater than if the detonator be placed at the lower end. If the detonation were instantaneous, the effects would be the same. Being progressive, the action is easily explained. This being granted—that time is a necessary element in detonation—there are facts which seem to show that special conditions are required to insure the *complete* explosion of nitro-glycerin and its compounds.

Mowbray noticed at the Hoosac Tunnel that weak detonators did not fully explode his charges of nitro-glycerin—a part was blown out in vapor. In mining with dynamite the atmosphere of the drift often becomes laden with the vapor of nitro-glycerin, giving tyros and even experienced miners the characteristic headache. (See article by Dr. Darlington, of Arizona, in the Scientific American Supplement No. 786, January 24, 1891, republished from the Medical Record.) This effect is a general complaint against nitro-glycerin preparations, and is *not usually attributable to weak detonators* but to improper loading. In rock blasting it can be prevented, in my opinion, by careful loading, proper placing of the detonator, and good tamping.

Returning to consider our charge of nitro-glycerin in the tin can or glass bottle, if we admit the possibility of some portions of the liquid escaping from the case before they are exploded, the conditions are right to preserve these particles from subsequent explosion. Being finally divided by the blow which scatters them, they would form instantly an emulsion with the surrounding water, and thus be protected. In support of the protection afforded by this condition, I can cite some facts from my own experience. It has been my fortune to inspect, immediately after the accident, the ruins of several nitro-glycerin explosions, where tons of the liquid went off, creating havoc with buildings, lead vats, and, unfortunately, sometimes with human bodies. One would naturally suppose that not a particle of nitro-glycerin within a radius of fifty feet would escape explosion. Buckets of the liquid one hundred and fifty feet away have been known to explode by "sympathy," blowing the Chinaman who was carrying them to pieces. Yet, when the ruins are overhauled, men handling the timber and litter get violent headaches, showing the presence of the liquid—in fact, it has been found in considerable quantity among the débris. The explanation is that this liquid

was at the time of the explosion an emulsion with either water or acid.*

The only strong argument against my suggested theory of a loss of nitro-glycerin is that the acute experimenters handling and firing many charges should have given it no countenance. However, General Abbot's experiments were made a good many years ago, when simpler views prevailed in regard to detonation, and nitro-glycerin was believed to be the quickest of explosives.

We will now consider his own explanation—a loss of energy in the medium transmitting the shock. If we admit that the liquid is all exploded and that its shock or initial energy is greater than that of dynamite, and yet when we measure the energies transmitted to the plugs through a foot or more of water, we find the dynamite registering more than the nitro-glycerin, the conclusion is inevitable that the intervening water has absorbed some of the energy, and the relative quantity absorbed is greater in the case of the nitro-glycerin than in the case of the dynamite ; in other words, the water has been heated more by the nitro-glycerin.

If the water were incompressible it would transmit the energy in both cases without diminution (except by the law of the square of the distance). Being compressible, if it were perfectly elastic, it would still transmit the energy undiminished in the ideal case, the heat of compression being balanced by the cold of expansion. Water for the purposes of this discussion *may be regarded as perfectly elastic*, and any *confined* portion of it will transmit energy undiminished. The law of its heating by compression was experimentally determined by Joule. If the heat is not allowed to leave it, it regains its original volume and temperature when the pressure is removed. In General Abbot's experiments the water was not confined, and part of the heat of compression may have been dissipated beyond the orbit of his registering plugs. We may suppose the relative loss was greater in the case of nitro-glycerin than dynamite. On this slender thread it seems to me his theory hangs.

*A charge of about 1700 pounds of nitro-glycerin, agitated in a lead "nitrator" or "mixer" with about four times its weight of acid, has been known to withstand the shock of nearly a ton of the liquid exploding within four feet of it. The mixer, with its lead coils still in it, torn from its foundations, thrown perhaps twenty feet and crushed into a shapeless mass, showed no signs of an explosion inside.

An equally perfect agitation with half as much water (as acid) would probably have the same protecting effect, the protecting effect being a question of specific heat.

Although I have held these theoretical views for a long time, it is only lately that I have attempted to test them by a practical experiment. My object was to prove whether or not there was anything in the nature of water which rendered it a better medium for transmitting the shock of dynamite than for transmitting the shock of nitro-glycerin. To the instrument designed for this purpose I have given the name "water crusher gauge."

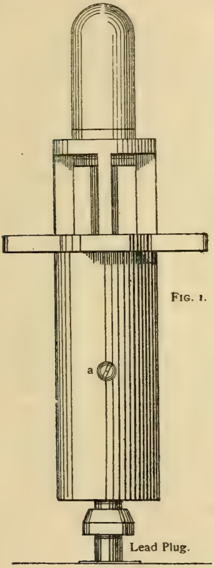


FIG. 1.

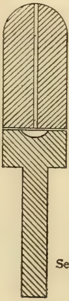


FIG. 2.
Section of Pistons and Shot.

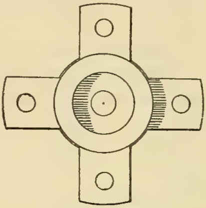


FIG. 4.—Top View.
Shot and Piston removed.

FIG. 3.

WATER CRUSHER GAUGE.

This instrument consists of a brass cylinder 4 inches in outside diameter, with a bore-hole exactly one inch in diameter. The extreme length is 14½ inches; 3¾ inches below the top are projecting lugs to rest on the ring of the Quinan gauge, to which they are firmly bolted. This brings the cylinder inside of the slides, the lower end being about 2½ inches above the steel block, upon which the lead plugs are crushed. Above the lugs the brass cylinder be-

comes a skeleton support and guide for the piston, and consists of a ring and four upright guides.

The pistons are of steel. The top piston has a total length of 6½ inches. The lower part, 1 inch in diameter and 5 inches long, is fitted to the bore of the cylinder. The upper part, 2½ inches in diameter, is fitted to slide between the guides and through the brass ring. The powder cavity is small, 1 inch in diameter and ⅜ inch deep. The lower piston is shorter, the portion fitted to the bore of the cylinder being 2½ inches long.

The shot is 5 inches long and 2½ inches in diameter.

The instrument is designed to transmit the blow through a column of water enclosed between the two pistons. The length of the column of water used was 6 inches.

The apparatus was so well made that the pistons were air-tight. When one was pushed in, the other was pushed out by the air.

In operating it, the lower piston was carefully oiled and inserted in place, and the cylinder bolted to the ring of the large crusher gauge. The lead plug was placed under the lower piston, and the bore-hole filled with water, the gauge being brought to the perpendicular for the purpose. The top piston, carefully oiled, was then entered. The small screw *a* on the side of the cylinder which communicates by a ⅛ inch hole with the bore, was then loosened, and enough water drawn off to allow the top piston to descend until exactly 6 inches of the column of water remained in the cylinder. The screw was then driven in tight with a screw-driver. The charge of explosive was placed in the cavity, the shot, with capped fuse already inserted in it, was placed on top, and the charge fired.

Castor oil was used to lubricate the pistons. During the experiments it was found advisable to support the top piston at the exact point by placing upright under it a piece of pine wood about the size of a parlor match, as the screw leaked slightly, unless driven home very hard, and allowed the piston to descend too far, especially when the weight was increased by putting on the shot.

The only defect developed during the trials was that the steel had not been tempered sufficiently hard. The cavity in the top piston became roughened by the gases and the fuse-hole in the shot considerably enlarged, which caused a falling off in the apparent strength of the different explosives; but as these were made to alternate in the firings, and a comparison only was aimed at, the defect was not serious.

The weights of the moving parts were as follows:

Weight of shot,	90	ounces.	
" " top piston	50	"	73.73 ounces.
" " lower "	21	"	
" " water	2.73	"	

" " middle piston, 5 ounces (to be described later).

The compressions were reduced to foot-pounds by the curve for soft lead plugs on Plate II, which curve was determined specially for these plugs.

The uniform charge selected was 10 grains, a small charge, but the delicate nature of the apparatus seemed to prohibit a very heavy shock. It will be seen that during the experiments it received such a shock and stood it very well.

The detonator used was a triple force cap, supposed to contain, beside fulminate, a small per cent. of gun-cotton. The caps were not as uniform as could be wished. In the preliminary experiments, made to determine their strength, the compression ranged from 104 to 132. The mean work of the cap was taken at 30 foot-pounds.

The experiments were as follows, it being understood that the tests were not in the order given, the results for each explosive being segregated:

Nitro-glycerin.—Anhydrous, several months old, charge 10 grains.

	Compression in $\frac{1}{1000}$ inch.	Foot-pounds.	Foot-pounds corrected for cap.	
	379	183	153	
	381	184	154	
Shot No. 6	$\boxed{669}$	$\boxed{600}$	$\boxed{570}$	anomalous, rejected.
	377	180	150	
	369	173	143	
		Mean work,	150	

Dynamite.—The dynamite was made from the same nitro-glycerin and German kieselgühr, 75 per cent. of the former and 25 per cent. of the latter, charge 10 grains.

Compression.	Foot-pounds.	Foot-pounds corrected.
336	147	117
323	137	107
308	127	97
310	129	99
	Mean work,	105

Ratio of mean work of dynamite to mean work of nitro-glycerine, $\frac{105}{150} = 70$ per cent.

Gun-cotton.—This was a very strong explosive, made by nitrating a fine hydrocellulose, which was obtained from cotton-waste. The gun-cotton was in fine powder, charge 10 grains.

Compression.	Foot-pounds.	Foot-pounds corrected.
312	130	100
310	129	99
	Mean work,	99.5

Ratio of work of gun-cotton to work of nitro-glycerin $\frac{99.5}{150} =$ 66.3 per cent.

This is probably low, as the gun-cotton was tried after the gauge had suffered some deterioration.

The ratio 70 per cent. for dynamite and nitro-glycerin, though a little low, is the ordinary crusher gauge effect, which, as proved by many experiments (including those of Drinker, already referred to) shows a strength for dynamite a little less than that due to the contained nitro-glycerin.

To test this anew, the water gauge was converted into an ordinary gauge by dispensing with the water column, and inserting between the two pistons the piece of steel shown in Fig. 3. This was made as light as possible, so as to approximate the weight of water for which it was substituted. It weighed really 5 ounces instead of 2.73, making the relative weights of the shot and compound piston 90 : 76 instead of 90 : 74, as in the water gauge.

This change had a slight effect in lessening the compression probably, but the compression was still more reduced by the lack of continuity in the compound piston. In these experiments, the middle piston being only 3¾ inches long, I used a steel plate ½ inch thick under the lead plug, and the joint between the top piston and the shot in the firing position came *below* the brass ring of the cylinder.

The caps were tried again, and their mean work averaged at 32 foot-pounds.

Nitro-glycerin.—Same as before, charge 10 grains, all steel compound piston.

Compression.	Foot-pounds.	Foot-pounds corrected.
346	156	124
321	136	104
	Mean work,	114

Dynamite.—Same as before, charge 10 grains, all steel compound piston.

Compression.	Foot-pounds.	Foot-pounds corrected.
298	120	88
280	108	76
	Mean work,	82

Ratio of work of dynamite to work of nitro-glycerin $= \frac{82}{114} =$ 71.9 per cent. This agrees well with experiments in the large gauge.

Gun-cotton.—Same as before, only one shot was fired with gun-cotton, charge 10 grains, all steel compound piston.

Compression.	Foot-pounds.	Foot-pounds corrected.
305	124	92

Ratio of work of gun-cotton to work of nitro-glycerin $= \frac{92}{114.5} =$ 80 per cent.

This is too large, but agrees fairly well with tests of this gun-cotton in the large crusher gauge.

The following observations were made with the water gauge: Sometimes both pistons rebounded slightly, and the lower piston was found a half inch or so above the lead. Usually the lower piston was found in contact with the lead. No loss of water could be detected by measuring the column of water, including the lengths of the pistons immediately after firing. No increase in the temperature of the water could be detected.

Shot No. 6 with nitro-glycerin is to be explained in this way. The proper firing position for the top piston is shown in the sketch. The joint between the piston and shot should be about ⅜ inch *above* the brass ring of the cylinder. In this shot the screw was not driven in tight, and when the shot was put in place the piston slowly sank during the burning of the fuse till the joint came well down in the ring. When the charge was fired the gauge was converted for the moment into a mortar, the gases being confined by the tight-fitting ring. The weight of the compound piston was also lessened by the

loss of water, but the influence of this was slight compared to the mortar effect of the ring. The result of the shot was the tremendous compression of the plug as shown, but this gives only a faint idea of the exhibition of power. The shot was thrown probably 40 feet into the air, *and was followed an instant or two later* by the top piston, which was thrown still higher, and fell at least a half second after the shot. Part of the water was also thrown out in a jet. The actual compression of the water must have been considerable to produce such effects. Unfortunately it was not measured.

In discussing the experiments with the water-crusher gauge, we think we are justified in saying that *there is nothing in the nature of water which makes it a better medium for transmitting the energy of dynamite than for transmitting the energy of nitro-glycerin.* It is not claimed that the conditions of explosion were the same as in General Abbot's experiments. I employed a *confined column* of water, acted upon by a steel piston of considerable weight. Under these conditions water seems to transmit the whole force of nitro-glycerin. It is undoubtedly compressed and heated, but the subsequent expansion and cooling restores the energy without sensible loss. If the experiment could have been conducted with a piston without weight, the expansion of the water might not have made this compensation, although there is no reason to believe that this would have been to the advantage of dynamite. In this case, if the explosive were quick enough to complete its work and then condense before the phase of water expansion set in, the expansion would be without effect on the plug. In my experiments the inertia of the piston served to make the expansion of the water contribute its quota to the crushing of the plug. In one experiment only, No. 6, did the inertia of the piston appear to be inadequate. In this instance a portion of the energy imparted to the water was not transmitted to the plug, but was expended by the rebound in projectile force.

Too much importance, however, must not be attached to this difference between my conditions and those of General Abbot. It is true, the blow of his charge was partly transmitted by water without the intervention of a block of steel having considerable weight (his piston being insignificant in this regard), but it must be remembered that his charges were incomparably larger, that they consumed a much larger interval of time in evolving their gases, and that the water acting upon the piston had in rear of it the sustaining

pressure of these gases, which must have acted somewhat like the inertia of my piston in directing the expansive force of the water, and, lastly, it must be noted that, at least in his larger charges, *his piston must have been acted upon directly by the gases themselves* for at least a portion of the period of explosion. The globe of gas must have extended far beyond the orbit of the plugs in some, if not all, of his charges.

The more the subject is considered the more strange the anomalous action of nitro-glycerin becomes, unless we adopt some very simple explanation, such as the loss of a portion of the charge in the surrounding water.

If this theory is correct the loss results from the incompressible nature of the liquid. There being no chance for expansion, the case is burst before the whole of the liquid is converted into gas, whereas with dynamite the interstitial spaces give a little time for this conversion before the pressure bursts the case. This theory could be easily tested. Divide the charge of nitro-glycerin among a number of very small, thin, glass bottles, the bottles being tared to get the weight of liquid. Fill each bottle not more than half full. Pack the bottles loosely into a strong case, using one as a primer. This experiment has the advantage of being perfectly feasible. If it gives a largely increased intensity of action for nitro-glycerin, we may regard the theory as proved. If it does not, then we have thrown no light upon the subject, and must "guess again."

Lead as a Register of Work.

Lead has a good deal to recommend it as a material to register work. In the first place, it is very sensitive; secondly, a plug already partly compressed will register a second blow very accurately, the work corresponding to the second blow being equal to the work corresponding to the total compression, less that belonging to the first compression; or, if the plug retains the cylindrical form after the first compression, we can treat it as a new plug of larger diameter and shorter length with a curve of its own.

General Abbot notices this valuable property of lead, and makes use of it in his experiments (see page 138 of his Report).

I have made some special experiments to test the accuracy of the principle in the foot-pounds machine, and found it quite reliable through a wide range of compressions.

The question whether the work indicated by a given compression in the foot-pounds machine is exactly equal to the work corresponding to the same compression by an explosive in the crusher gauge has been mooted before. That it is approximately the same I have no doubt, but there are good reasons for believing that the agreement is not generally exact. If the two compressed plugs show the same form, we are entitled to think that the same resistance was developed, and in the same way. In my experience there is less difference in form when the lead is hard, and I therefore regard this material as the best. Soft plugs are more regular in form when compressed by a falling weight than by an explosive. When compressed by a weight they are cylindrical for small compressions and barrel-shaped for great compressions, the top and bottom remaining equal, or nearly so, in area. When the plug is compressed by a high explosive, the higher compressions are tub-shaped.

This difference of form implies a difference in the law of the resistance, and probably a difference in the amount of work. The most plausible explanation of this difference of form that occurs to me is a difference in the law of action.

In the case of the falling weight the first part of the compression is done rapidly; the action is a maximum at the beginning and decreases by a regular law. In the case of the high explosive the action begins as zero and rises to a maximum, and then falls to zero again. If the maximum is very near the close of the action, there may not be time for the flow of the metal to be equalized. The heat developed by the blow *softens the top part of the plug, which consequently spreads faster than the bottom.*

The same effect takes place with the falling weight at or near the beginning, but the effect is masked by the subsequent compression. Whether or not the *total time* of action is greater or less in the case of the explosive or the falling weight is a nice question.

General Abbot concluded, in his experiments, that the action of the pendulum hammer was much shorter in period than his high explosives. This might well be, as his charges were incomparably larger than crusher gauge charges and acted through a foot or more of water, whereas in the crusher gauge, from the arrangement of parts and the smallness of the charge, the time required to detonate the charge and complete its action on the plug must be very short; nevertheless, we believe the hammer or weight was quicker in its action in

performing the same work, for the simple reason that it begins its action as a maximum, whereas every explosive must begin as zero and develop its maximum action during the course of the work. We regard the *hammer action as a limit which explosives may approximate but can never reach.* This is not a rigorous demonstration, however, and I only offer it for what it is worth. We will touch upon this subject again.

A question allied to the one we have been discussing, viz., the equality between work by a falling weight and work by an explosive, is this: Is the compression by a falling weight the same for a given number of foot-pounds whether the latter be made up of many feet and few pounds or few feet and many pounds?

This it was easy to decide in the affirmative for at least *the range of the apparatus* by a few experiments in the foot-pounds machine.

Copper as a Register.

There is another metal used to register the effects of forces in crusher guages—copper. The parent form of the instrument was Rodman's indenting piston and copper disc. When Rodman first proposed this for measuring the powder pressure in guns, the theory of its operation was criticised by Professor Bartlett, of West Point. The practical usefulness of the Rodman guage has been proved by many years' experience. Any error in the theory of its application affects equally the crusher form of the apparatus. The quantity aimed at in gun experiments is the maximum pressure or the maximum intensity of action, supposed to be represented by the final resistance to either the cutter or the crusher piston. The scale of pressures (that is, the reading for the cuts or compressions) is determined in our service, and I think also in Europe, by a testing machine sometimes called erroneously a dynamometer, a simple arrangement for weighing the pressure which is applied by a screw to the copper cylinder or discs. The staging supporting the copper is connected with a system of levers, one of which has a sliding weight to counterbalance and measure the pressure. It is assumed to be a fact with copper of a given quality that if the screw be driven *slowly*, the length of the cut of the indenting tool or compression of the cylinder is practically the same for the same pressure. When a certain cut or a certain compression has been made, the disc or cylinder can be replaced in the apparatus, and the same pressure applied without increasing either cut or

compression, provided it is applied slowly. General Abbot quotes the experience of English artillerists who found that a copper cylinder, compressed by a charge of gunpowder in a 12.5-inch gun, retained its reduced length unaltered, when the trial was repeated several times. The powder was a slow-burning, large-grain, 1.5-inch cubical. With lead, however, the case is quite different. Small pressures maintained for considerable periods produce the same results as larger pressures for shorter periods. For this reason General Abbot found it impossible to prepare a reliable scale for his plugs with the Rodman testing machine.

This difference of the two metals, notwithstanding that the practice of artillery experts may be properly based upon it, must be one of degree, due to the great difference in hardness, so that the above statements in regard to copper are to be received cautiously. In view of the fact that the resistance offered by lead is so susceptible to the influence of time, we may assume that copper resistance is not altogether independent of it. The use of the scale so determined to measure the effects of powder charges in guns has been criticised upon the general grounds that the action of explosives is analogous to a blow, and that ordnance experts confuse static and dynamic effects in treating this action as a pressure. Without giving any opinion at present upon the validity of this criticism, we may say one thing seems evident—the cut made by the indenting tool or compression by the piston, whether done in the testing machine or in a gun, is a register of *work*.

Dynamic Treatment of Copper.

I have, therefore, thought it well to treat some copper cylinders in the same way as lead plugs in the foot-pounds machine, and to determine the relation between the work and compression. Having these quantities, the mean resistance is easily obtained by dividing the work expressed in foot-pounds by the compression expressed in feet. This quantity, however, is not what ordnance experts aim at. For their purposes the crucial quantity is the maximum intensity or pressure, supposed to be represented by the maximum resistance of the copper. This we are not so certain of, but will do our best to determine also.

The cylinders were obtained from the Benicia Arsenal. They were .25-inch diameter and .5 inch long. Captain Rockwell, of the

Ordnance Department, had the following scale of pressures determined for me on the testing machine:

Measured Pressures Corresponding to Compression of Copper Cylinders, ¼" x ½".

Original length.	Reduced length. Inches.	Compression. Inches.	Pressure. Lbs. on the sq. inch.
.502	.420	.080	21,250
	.412	.090	25,000
	.392	.110	27,500
	.383	.119	30,000
	.370	.132	32,500
	.352	.150	35,000

As a preliminary to my experiments, I prepared a number of weights bearing simple relations to each other, as follows: I took a piece of steel shafting, exactly 2 inches in diameter, and cut it up in a lathe into cylinders 24, 12, 8, 4, and 2 inches in length. I also built a foot-pounds machine specially for these weights.

For my first set of experiments in the foot-pounds apparatus, I selected as my weight the piece of 2-inch steel shafting, 8 inches long, weighing 7.0625 pounds. I found that nearly all the copper cylinders measured within less than $\frac{1}{1000}$ of an inch of .499" in length, whereas Capt. Rockwell gives .502" as their length. This difference was doubtless due to an index error in one of our calipers, but this was unimportant, as the reading of the compression would not be affected thereby.

The following table was made in this way: I dropped the weight from successive heights, beginning with one foot and going up one foot higher each time. At any point where there seemed to be any anomaly in the compression, the experiment was repeated till the doubt was settled. I then began again at 6 inches and went up one foot at a time, so as to get interpolations, anomalies being treated as before. The cylinders proved to be remarkably uniform in their resistance. They retained the cylindrical form very accurately up to a compression of about one-third of their length; beyond this they were barrel-shaped. Under the heavier impacts of the piston a decided rise in temperature was noticed when the little plug was picked up. This was of interest, as the mechanical equivalent of

heat has been determined by this method. I have taken the trouble to calculate the theoretical rise of temperature.*

I made, also, some experiments to determine whether there is any radical difference between copper and lead as registers of work. I *found that a copper cylinder, partly compressed, will record a second blow, and even a third or greater number with the same or even greater accuracy than lead.* I also proved, by changing my weight, using the 24, 12 and 2-inch pieces of shafting, that the recorded work is independent of the relation of the factors, provided their product is constant—that is, a piston 8″ long dropped 2 feet is equal in effect on the copper cylinder to a 2-inch dropped 8 feet. I also proved that the *copper is sensitive enough to record a very small work, even when already highly compressed.*

If we compare the following table with the data already compiled for lead plugs, we will find that the curve for the copper cylinders falls between the curves for the .75-inch and 1-inch (soft) lead plugs, being nearer the latter; that is, a copper cylinder .25 inches in diameter and .50 inches long gives *about* the same curve as a lead cylinder .93 inches in diameter and 1 inch long. As the sectional areas of the copper and this lead are as 1 to 14, if we take into account the average effect of the difference in length which we can estimate from our general equation, $x = \frac{K A L y^a}{L - y}$, which effect increases with the compression, we can say roughly that the ratio of the *sensitiveness* of the two materials to *dynamite* compression is 1 to 10; that is, copper requires ten times as much work as lead to produce equal compressions.

* The calculation of the rise in temperature is made for a fall of 10 feet, giving 70.625 foot-pounds = .09148 British heat units, calling a Joule 772 foot-pounds. The specific heat of copper being .0930, this would raise .9836 pounds (not quite one pound) of copper one degree Fahrenheit. The average weight of the copper cylinders is 3.552 grammes. The number to the pound is 127.7, the number to .9836 pounds is 125.8, which is the number of degrees Fahrenheit this work would raise the temperature of the cylinder. If the primitive temperature were 60°, this would make the temperature of the copper 185°.8, provided, of course, there was no loss. If the crushing were done on a non-conducting surface, the plug would be hot enough to burn the fingers.

The same amount of work would not raise the temperature of the one-inch lead plugs noticeably. Taking their average weight at 145 grammes (40.82 times the copper), the specific heat of lead being .0315, the rise in temperature would be

$$125^\circ.8 \times \frac{2.952}{40.82} = 9^\circ.09 \text{ Fahr.}$$

Table No. 1.

First Set Experiments, Copper Cylinders Crushed by Falling Weight. Weight, 2″ Steel Shafting, 8″ long, Weighing 7.0625 *Pounds. Copper Cylinders, .25″ diameter, .499″ long.*

Drop in feet.	Work, foot-pounds (x).	Reduced length of cylinder in $\frac{1}{1000}$ inch.	Compression (y) in $\frac{1}{1000}$ inch.	Mean resistance, $\frac{x}{y}$
0.5	3.531	465	34	.104
1	7.0625	443	56	.126
1.5	10.594	427.5	71.5	.148
2	14.125	412	87	.162
2.5	17.66	400	99	.178
3	21.187	389	110	.192
3.5	24.72	378	121	.204
4	28.25	367	132	.214
4.5	31.78	357	142	.224
5	35.31	349	150	.235
5.5	38.84	338.5	160.5	.242
6	42.37	331	168	.252
6.5	45.91	323	176	.261
7	49.44	314	185	.267
7.5	52.97	306	193	.274
8	56.50	299	200	.282
8.5	60.03	292	207	.290
9	63.56	285	214	.297
9.5	67.09	280	219	.306
10	70.62	273	226	.312
10.5	74.16	268	231	.321

In this table thousandths of an inch have been treated as whole numbers. It will be noticed that the mean resistance increases pretty regularly with the compression. The curve corresponding to this table will be found plotted on a small scale on Plate III (see Fig. 1). In order to deduce an equation for the curve, I have taken from the latter the following list of new co-ordinates:

$y = 25$	$x = 2.4$
$y = 50$	$x = 6.4$
$y = 75$	$x = 11.7$
$y = 100$	$x = 18$
$y = 125$	$x = 25.8$
$y = 150$	$x = 35.3$
$y = 175$	$x = 45.5$
$y = 200$	$x = 57$
$y = 225$	$x = 70$

These figures have no pretence to minute accuracy, the scale used for the curve being small.

Assuming the equation used for lead plugs,

$$x = \frac{By^a}{499 - y},$$

we calculate the values of B and a by taking the above co-ordinates in sets of two, and find that the curve can be represented pretty accurately by the following simple equation:

$$x = \frac{18y^{1.3}}{499 - y}.$$

The following list of co-ordinates has been calculated from it:

$y = 25$	$x = 2.5$
$y = 50$	$x = 6.5$
$y = 75$	$x = 11.6$
$y = 100$	$x = 18$
$y = 125$	$x = 25.6$
$y = 150$	$x = 35.5$
$y = 175$	$x = 45.8$
$y = 200$	$x = 59$
$y = 225$	$x = 74.8$

The curve represented by the equation is given in Plate III (see Fig. 1). When applied to the first curve the agreement up to a compression of 175 is very close; beyond this the new curve inclines to the right, but for our present purpose this is immaterial.

Now we will attempt to calculate the maximum resistance corresponding to different compressions, the quantity aimed at in gun experiments. For the range of such experiments the relation between *work* and compression *seems* to be quite accurately represented by the equation

$$x = \frac{18y^{1.3}}{499 - y}.$$

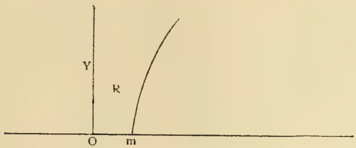
Differentiating this, we have

$$\frac{dx}{dy} = \frac{18 \times 1.3\,(499 - y)\,y^{.3} + 18y^{1.3}}{(499 - y)^2}.$$

an expression for the tangent of the angle, which this curve makes with the axis of Y.

This curve gives the relation between the work (x), and compression (y).

If we now suppose the curve expressing the relation between the compression (y) and the *resistance* (R) to be constructed, and the initial resistance Om to be equal to R',



then the work x will be the area included between the curve and the axis of Y.

Let us assume

$$R = \frac{dx}{dy} = \frac{18 \times 1.3\,(499 - y)\,y^{.3} + 18y^{1.3}}{(499 - y)^2}.$$

Then since $x = \int R dy$, we have

$$x = \int \left(\frac{18 \times 1.3\,(499 - y)\,y^{.3} + 18y^{1.3}}{(499 - y)^2} \right) dy;$$

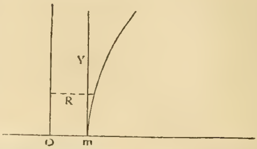
whence $$x = \frac{18y^{1.3}}{499 - y} + C,$$

which we know to be correct, since the constant C is zero.

But R cannot be equal to $\frac{dx}{dy} = \frac{18 \times 1.3(499 - y)\,y^{.3} + 18y^{1.3}}{(499 - y)^2}$ because this quantity is equal to zero when $y = 0$, whereas R by hypothesis is equal to R'; so we conclude that the form of our equation $\left(x = \frac{By^a}{L - y} \right)$ is defective for our present purpose. The defect of this form of equation is that it gives a curve *tangent* to the axis of Y at the origin, whereas the curve should make an angle with this axis at the origin, the tangent of which is equal to the initial resistance.

If we consider the work due to the initial resistance and the path separately from the work due to resistances developed by com-

pression and increase of area, and call the latter z, we have $x = z + R'y$, in which z will represent the area included between the R, y curve and a new axis of Y drawn through the point m.



We can determine the values z from the equation $z = x - R'y$, if we know the values R' and x. We can get the values of R' *approximately*, if we have a suitable table of values of x, by determining x when $y = 1$. If we suppose the R, y curve to be a straight line between the origin and this small value of y, then this value of x will be the resistance for $y = \frac{1}{2}$. Moreover, if we can express the value of z by an equation of the form $z = \dfrac{By^a}{L - y}$, the z, y curve will be tangent to the new axis of Y at the origin, and R for $y = \frac{1}{2}$ will be practically equal to R for $y = 0$, or R'.

The first step was, therefore, to construct a new table of small values for x. For this purpose I prepared a small foot-pounds machine and used as my weight the 2-inch piston, weighing 1.766 pounds. To insure greater accuracy in measuring the cylinders, both before and after compression, I attempted to divide the $\frac{1}{1000}$ of an inch. In the following table I give the original experiments except a few rejected as failures.

TABLE No. 2.

Second Set Experiments with Falling Weight (Foot-pounds Machine) on Copper Cylinders. Weight 2" long, 1.766 pounds.

Drop in inches.	Work, foot-pounds (x).	Original length of cylinder ($\frac{1}{1000}$ inches).	Reduced length of cylinder ($\frac{1}{1000}$ inches).	Compression in ($\frac{1}{1000}$ inches).	Average compression ($\frac{1}{1000}$ inches).	Mean R. $\frac{x}{y}$
¼	.0368	499.3	499	.3	.3	.123
¼	.0368	499.7	499.4	.3		
½	.0736	499.4	498.5	.9	1.17	.063
½	.0736	499.5	498	1.5		
½	.0736	499.6	498.2	1.2		
½	.0736	499.6	498.3	1.3		
½	.0736	499.6	498.6	1.		
½	.0736	469.5	498.4	1.1		

Drop in inches.	Work, foot-pounds (x).	Original length of cylinder ($\frac{1}{1000}$ inches).	Reduced length of cylinder ($\frac{1}{1000}$ inches).	Compression in ($\frac{1}{1000}$ inches)	Average compression ($\frac{1}{1000}$ inches.)	Mean R. $\frac{x}{y}$
¾	.1104	499.7	498	1.7		
¾	.1104	499.6	498.2	1.4	1.57	.070
¾	.1104	499.7	498.1	1.6		
1	.147	499.5	497.6	1.9		
1	.147	499.5	497.4	2.1		
1	.147	499.6	497.6	2.0	2.025	.072
1	.147	499.3	497.2	2.1		
2	.294	499.3	494.6	4.7		
2	.294	499.6	495	4.6	4.57	.064
2	.294	499.4	495	4.4		
3	.442	499.2	492.5	6.7		
3	.442	500.1	492.8	7.3	6.6	.067
3	.442	499.2	493	6.2		
3	.442	499.4	493.2	6.2		
4	.589	499.2	490.6	8.6		
4	.589	499	490	9.0	9.1	.065
4	.589	500	490.5	9.5		
4	.589	499.3	490	9.3		
5	.736	499.2	488	11.2	10.95	.067
5	.736	499.	488.3	10.7		
7	1.030	499.5	485.5	14	14.	.074
9	1.324	499.3	481.4	17.9	17.9	.075
12	1.766	499.	476.9	22.1	22.1	.080
15	2.207	499.6	474	25.6	25.6	.086
18	2.659	499	470	29	29.	.092
24	3.532	499	464.5	34.5	34.5	1.02

This table cannot be regarded as a complete success; according to the theory which we have adopted the mean resistance should be nearly constant for very small compressions and then increase slowly, whereas it begins with a value .123 and then drops to .063. Some importance is to be attached to this latter value as it was the mean result of six experiments. A law of increase in the mean resistance is noticed, beginning at the 2 inch drops; with some irregularities, it is true, and probably from this point the table is fairly reliable. If we had to decide the question from this table, we would

say that the initial resistance is approximately .063. For the present we reject the data below 2 inches.

For the higher compressions the apparatus worked well, and the accepted data may be regarded as a supplement to the table determined before with the 8-inch piston, with which it connects very well. My next move was to construct a more delicate apparatus—a miniature foot-pounds machine in which the weight was a polished steel cylinder ⅝ inch in diameter and 3 inches long. The anvil consisted of a steel rod of the same diameter, 15 inches long. The results with this apparatus are given in the following table. I expected great things from it and was proportionately disappointed, as will be seen in due course.

Table No. 3.

Third Set of Experiments with Foot-pounds Machine and Copper Cylinders. Weight ⅝″ x 3″, .259 pounds.

Fall in inches.	Work, foot-pounds (x).	Original length of cylinder ($\frac{1}{1000}$ inches).	Reduced length of cylinder ($\frac{1}{1000}$ inches).	Compression (y) ($\frac{1}{1000}$ inches).	Average compression ($\frac{1}{1000}$ inches).	Mean R. $\frac{x}{y}$
½	.01079	499.9	499.8	.1	.1	.108
¾	.01618	499.6	499.5	.1	.1	.162
1	.02158	499.5	499.3	.2	.2	.108
1	.02158	499.6	499.4	.2		
1½	.03237	499.6	499.4	.2	.2	.162
1½	.03237	499.7	499.5	.2		
1½	.03237	499.6	499.6	0.0		rejected
1¾	.03776	499.7	499.4	.3	.3	.126
1¾	.03776	499.7	499.4	.3		
2	.04316	499.8	499.4	.4	.4	.108
2½	.05395	499.5	499	.5	.5	.108
3	.06475	499	498.4	.6	.65	.100
3	.06475	499.7	499	.7		
3½	.07553	499.6	498.7	.9	.95	.079
3½	.07553	499.6	498.6	1.0		
4	.0863	499.2	498.1	1.1	1.1	.078
5	.1079	499.4	498	1.4	1.4	.077
5	.1079	499.5	498.1	1.4		
6	.1295	499.5	497.8	1.7	1.7	.076

Fall in inches.	Work, foot. pounds (x).	Original length of cylinder ($\frac{1}{1000}$ inches).	Reduced length of cylinder ($\frac{1}{1000}$ inches).	Compression (y) ($\frac{1}{1000}$ inches).	Average compression ($\frac{1}{1000}$ inches).	Mean R. $\frac{x}{y}$
7	.1511	499.5	497.5	2.0	2.0	.075
9	.1942	499.6	497	2.6	2.6	.075
12	.259	499.4	495.7	3.7	3.6	.072
12	.259	499.5	496.	3.5		
14	.3022	499.8	495.5	4.3	4.2	.072
14	.3022	499.2	495.1	4.1		
16	.3453	499.6	494.8	4.8	4.8	.072
18	.3885	499.2	493.9	5.3	5.3	.073
21	.4532	499	492.8	6.2	6.2	.073
24	.518	499.4	492.3	7.1	7.1	.073
28	.604	499.3	491	8.3	8.4	.072
28	.604	499.5	491	8.5		
31	.669	499.5	490.5	9.0	9.2	.073
31	.669	499.7	490.3	9.4		
35	.755	499.2	489.3	9.9	10.0	.075
35	.755	499.5	489.4	10.1		
38	.8202	499.6	488.9	10.7	10.65	.077
38	.8202	496.6	489	10.6		

In examining this table we are struck with the irregularity of the mean resistance for the smaller drops. This was to be expected, to a certain extent, as the compression below $\frac{1}{1000}$ is, more or less, guessed at. It is curious, however, that the mean resistance should be so large for very small values of x, an anomaly noticed before, to a slight extent, with the 2-inch piston. Below 3½ inches fall the table is valueless. This table should connect with the previous one, but we find that it does not.

In the previous table a compression of 9.2 corresponds to .604 foot-pounds. In this table it corresponds to .669 foot-pounds. The reason, however, is not far to seek. With this light piston there was a decided *rebound*. In some cases the rebound was sufficient to allow the copper cylinder to turn over on its side. This trouble was experienced very slightly with the 2″ piston, but was neglected as unimportant. It the present case it vitiated the whole work. The rebound was not uniform. It was decidedly greater on some plugs than on others, when the falls were equal. *It was greater for small*

falls than for large, but could be noticed up to the last. I roughly estimated at about 30 inches fall that the upward rebound was ¼ inch. At 1½ inches it was nearer ⅜ inch. Now what did this rebound mean? Did it mean that the compression was within the elastic limit of the copper and that part of the compression was restored? On this point one experiment is instructive. One of the 1½ falls gave a remarkably high rebound, fully half an inch, and the copper cylinder turned over on its side. The compression was found to be *nil.* To test the cylinders for elasticity I dropped them endwise from varying heights up to about 15 inches upon a steel plate. They rebounded more or less. The greatest height of rebound was estimated at ⅜ inch. The *miniature foot-pounds apparatus developed individual differences in the copper cylinders, the presence of which was unsuspected.* These irregularities were probably due to the effect of the tool used to turn off the ends. It is necessary to say, however, that these differences would have been insignificant in ordinary work.

The effect of the rebound was to increase the apparent mean resistance, and the results of the table agree with observation. The rebound was greatest for small drops, likewise the values of the mean resistance given in the table. General Abbot, in his experiments with the pendulum hammer on lead plugs, observed a rebound, and corrected the fall by deducting the fall due to the rebound or recoil. I have no doubt he proved this correction sufficient. In the present case, even if I had been able to estimate the height of rebound accurately, it would not have been a sufficient correction. The error is too large. Assuming the data obtained with the 2″ piston to be correct, the error averages about $\frac{1}{7}$ of the fall. A very slight rebound was observed at very small heights with the 2″ piston. It remained to determine whether the irregularities of this table (page 550) were due to this cause. If by using a heavier piston the average mean resistance were reduced, it would show that the 2″ piston was also unreliable.

For this test I selected a piston 4 inches long, having exactly twice the weight of the 2″.

TABLE No. 4.

Fourth Set of Experiments, with Foot-pounds Machine and Copper Cylinders. Weight 4″ long, 3.532 pounds.

Fall in inches.	Equivalent fall for 2″ weight (inches).	Work, foot-pounds (x).	Original length of cylinder ($\frac{1}{1000}$ inches).	Reduced length of cylinder ($\frac{1}{1000}$ inches).	Compression (y) ($\frac{1}{1000}$ inches).	Mean R, $\frac{x}{y}$.	Mean R for 2″ weight.
¼	½	.0736	499.3	498.1	1.2	.064	.063
¼	½	.0736	499.4	498.3	1.1		
½	1	.147	499	496.7	2.3	.064	.072
1	2	.294	499.4	495	4.4	.067	.064
2	4	.589	499.1	490	9.1	.065	.065
2½	5	.736	499.1	488.6	10.5	.069	.067
3½	7	1.030	499.2	485	14.2	.072	.074
4½	9	1.324	499.7	482	17.7	.075	.075
6	12	1.766	499.5	478	21.5	.082	.080

In the last two columns I have compared the mean resistance with that of the former table for the 2″ piston. It will be seen that there is a substantial agreement, *one table serving to correct the anomalies of the other.* The data of this last table is scanty, but this could not be helped as my supply of cylinders was exhausted. This was regrettable as the apparatus worked very well. No rebound could be detected.

In regard to assuming a figure for the initial resistance the best we can do is to accept .062, which is certainly a very close approximation.

By combining the results of tables Nos. 1, 2 and 4 and constructing a curve on any convenient scale, we can easily get rid of the slight anomalies present. My plan for doing this is to plot all the points given by the tables and prick these on a thin board. With a sharp knife I cut the edge of the board to a curve passing as nearly as possible through these points, and finish the curve with a very small plane and emery cloth. Points which are too prominent are cut away, those which are reëntrant are left inside of the curve. The wooden template, when finished, is used to draw a new curve from which new co-ordinates may be taken. The results of this work are given in the following table.

It was my original intention to obtain the values of R by first getting a table of values of z from the expression $x = .062y + z$ and

then deducing an equation for the z, y curve of the form

$$z = \frac{By^a}{499 - y};$$

R would then be equal to $.062 + \dfrac{dz}{dy} = \dfrac{dx}{dy}$.

But it was essential that the equation $z = \dfrac{By^a}{499 - y}$ should be reliable for both very small and large values of y. I found great difficulty in fulfilling these exacting conditions, and concluded to abandon the method. My results would have been inaccurate at best.

I obtained the values of R, corresponding to different ordinates, by constructing tangents to the x, y curve at the extremities of the ordinates, and determining the tangent of the angle which these tangents made with the axis of Y—a practical determination of $\dfrac{dx'}{dy'}$. The x, y curve for the purpose was drawn on a large scale. I then constructed an R, y curve from the values of R found, and got rid of anomalies as usual. The x, y curve and R, y curve will be found on a reduced scale on Plate III, Fig. 2. (The x, y curve is substantially the same as in Fig. 1.) I have roughly checked the values of R given in the table in several ways. In the first place, it is evident that in a curve of the form of the x, y the tangent of the angle corresponding to a given ordinate as y', will be greater than the difference between the values of x for $y' - 1$ and y', and will be less than the difference between the values of x for y' and $y' + 1$. This follows, since the curve continually increases its curvature from the axis of Y.

I give a series of these differences in the values of x in the table for comparison with the values of R.

Secondly, we have a check in the equation

$$x = \frac{18y^{1.3}}{499 - y},$$

from which we have

$$R = \frac{dx}{dy} = \frac{18 \times 1.3\,(499 - y)\,y^{.3} + 18y^{1.}}{(499 - y)^2},$$

which is quite accurate below $y = 200$, except for very small values of y.

Lastly, I have made a practical integration on section paper of the area between the R, y curve and the axis of x for various ordinates, and compared this area with the corresponding value of x, and

found in every case a substantial agreement. I therefore believe the values of R to be approximately correct.

Table showing Relation between the Work, Compression and Resistance of Copper Cylinders (25 × .50), *crushed by a Falling Weight.*

y = compression expressed in thousandths of an inch.
x = kinetic energy of the weight (work), expressed in foot-pounds.
R = resistance of the copper expressed in units of 12,000 pounds.

y	x	Difference in value of x for 1 y.	R	Mean R. $\frac{x}{y}$
0	.0		.062	.0
		.063		
1	.063		.064	.063
		.065		
2	.128		.065	.064
		.066		
3	.194		.066	.065
		.068		
5	.330		.070	.066
		.074		
10	.700		.078	.070
		.080		
15	1.10		.090	.073
		.094		
20	1.57		.102	.078
		.112		
25	2.13		.118	.085
		.134		
30	2.80		.135	.093
		.154		
40	4.34		.156	.108
		.171		
50	6.05		.178	.121
		.193		
60	7.98		.200	.133
		.212		
70	10.10		.222	.144
		.232		
80	12.42		.245	.155
		.258		
90	15.00		.268	.167
		.285		
100	17.85		.290	.178
		.308		
110	20.93		.311	.190
		.331		
120	24.24		.329	.202
		.346		
130	27.70		.348	.213
		.358		
140	31.28		.365	.223
		.372		
150	35.00		.382	.233
		.390		
160	38.90		.401	.243
		.410		
170	43.00		.422	.253
		.430		
180	47.30		.444	.263
		.450		
190	51.80		.467	.273
		.473		
200	56.53		.501	.283
		.512		
210	61.65		.538	.294
		.560		
220	67.25		.577	.305
		.617		
230	73.42		.620	.319

It only remains to convert the resistances into pounds. Our values of x, numerically equal to the foot-pounds, are really made up of very different units. A unit of work consists of two factors, one representing force—a weight or pressure—the other a path or distance. A foot-pound is equal to twelve pound-inches or twelve-thousandth of an inch. In the present case, the unit of the path being $\frac{1}{1000}$ of an inch, the unit of intensity is 12,000 pounds, the quantity by which it is necessary to multiply the values of R to convert them into pounds. The value of R thus obtained represents the intensity of the force in pounds necessary to produce the corresponding compression of the cylinder (see Table 5, below). Two values are given: one, the mean value, supposes the resistance constant throughout the path; the other is intended to be an actual measure of the intensity of the force or the resistance at the instant of maximum compression.

Comparison of Dynamic Resistances and Rodman Pressures.

To get a comparison of my resistances with the pressures obtained with the Rodman testing machine, I wrote to Captain Rockwell for a more complete table. He sent me a table made by himself, ranging from a compression of .21 to .228; also a very complete table made at Frankford Arsenal, in 1890, for the same cylinders, ranging from a compression of .44 to .260. The agreement between the two is very close, showing that the indications of the testing machine are reasonably positive. The Frankford table is given below. In the original the reduced length of the cylinder only is given. To get the compressions I have assumed the original length to be exactly 500. In the original table the pressure given is "on the square inch." As the piston used had a sectional area of $\frac{1}{10}$ inch, I have divided these numbers by 10 to get the pressure on the cylinder. Following is the table in condensed form.

Table of Pressures on Copper Cylinders.

Rodman Testing Machine, Frankford Arsenal, 1890. *Original Table Abridged.*

Reduced length of cylinder ($\frac{1}{1000}$ inches).	Compression ($\frac{1}{1000}$ inches).	Pressure (pounds).
456.4	43.6	1500
451.9	48.1	1600
447.2	52.8	1700
442.3	57.7	1800
438.4	61.6	1880
434.1	65.9	1960
430.2	69.8	2040
426.0	74.0	2120
421.9	78.1	2200
417.6	82.4	2280
413.3	86.7	2360
404.6	95.4	2520
400.2	99.8	2600
389.1	110.9	2800
378.2	121.8	3000
366.8	133.2	3200
356.0	144.0	3400
344.9	155.1	3600
334.1	165.9	3800
323.5	176.5	4000
298.6	201.4	4500
276.8	223.2	5000
257.4	242.6	5500
241.0	259.0	6000

To obtain the interpolations needed for direct comparison with my resistances, I plotted the foregoing data on a large scale and obtained a remarkably regular curve which bears a marked general resemblance to my R, y curve (see Plate III, Fig. 3, in which both are given on a reduced scale). I took the required data from this curve, and it will be found in the last column of the following table, which is a summary of my work on copper cylinders in the foot-pounds machine. (The "dynamic pressure" curve in Fig. 3, Plate III, is the same as the "resistance" or R, y curve in Fig. 2, the abscissas being distorted by the use of a different scale in the two figures.)

TABLE NO. 5.

Table Showing Work, Compression, and Resistance of Copper Cylinders Compressed by a Falling Weight; also Rodman Pessures.

Compression (y) ($\frac{1}{1000}$ inches).	Work (x) (foot-pounds).	Resistance, final intensity of force (R) (pounds).	Mean resistance $\left(\frac{x}{y}\right)$ (in foot-pounds).	Rodman pressures (Frankford) (P) (pounds).		Ratio $\left(\frac{R}{P}\right)$
1	.063	768	756	510	hypothetical, taken from curve.	1.5
2	.128	780	768	....		....
3	.194	792	776	....		....
5	.330	840	792	....		....
10	.700	936	840	720	hypothetical,	1.3
15	1.10	1080	880	840	from the curve.	1.3
20	1.57	1224	942	955	Rockwell.	1.3
25	2.13	1416	1022	1070	"	1.3
30	2.80	1620	1120	1200	"	1.3
40	4.34	1872	1302	1410	Frankford.	1.3
50	6.05	2136	1452	1630		1.3
60	7.98	2400	1596	1845		1.3
70	10.10	2664	1731	2045		1.3
80	12.42	2940	1863	2240		1.3
90	15.00	3216	2000	2420		1.3
100	17.85	3480	2142	2605		1.3
110	20.93	3732	2283	2795		1.3
120	24.24	3948	2424	2975		1.3
130	27.70	4176	2557	3145		1.3
140	31.28	4380	2681	3325		1.3
150	35.00	4584	2800	3505		1.3
160	38.90	4812	2919	3690		1.3
170	43.00	5064	3035	3870		1.3
180	47.30	5328	3153	4060		1.3
190	51.80	5604	3272	4265		1.3
200	56.53	6012	3391	4460		1.3
210	61.65	6456	3523	4660		1.4
220	67.25	6924	3668	4875		1.4
230	73.42	7440	3831	5110		1.4

In the above table the "Rodman pressures" (5th column) below a compression of 20 are hypothetical—obtained by prolonging the

curve. Between 20 and 40 they are from Captain Rockwell's data. Comparing the "resistances" with "pressures," there is no close agreement, but a constant ratio of 1.3 between the two, except near the two extremes of the table, and there the ratio is either 1.4 or 1.5 (compare curves on Plate III, Fig. 3). This result, when it is considered by what very different methods the two series of numbers were obtained, is certainly remarkable.

Low and High Forms of Copper Resistance.

It appears from this that the resistances developed in the falling weight machine are uniformly about 1.3 times the pressures as determined slowly in the Rodman testing machine. Both are intended to measure the intensity of the force which is in equilibrio with the copper resistance corresponding to a given compression. Which is right? Probably both; that is, the resistance of the copper varies with the circumstances of the compression. It offers greater resistance when the compression is hurried, and less when the compression is slow. In this respect, therefore, copper resembles lead. The difference between them is one of degree only, as we predicated upon *à priori* principles. In lead we have seen that the property is so marked that a practicable scale cannot be made with the testing machine. To support our reasoning we bring to our aid the authority of Prof. R. H. Thurston, one of the members of the celebrated U. S. Board for testing metals, which a few years ago discovered and formulated the *law of the elevation of the limit of stress of iron.* Prof. Thurston found that copper, tin and lead formed a class of metals opposite in their qualities to iron. They have no elevation of the limit of stress, but oppose increased resistance to sudden strains and a lessened resistance to slow strains.

The only other investigator in this special field is General Abbot. He made a comparison of pressure and shock upon copper discs, using Rodman's indenting piston—not the curved, but the angular or pointed cutter, the angle being 163°30′ made by the two parts of the wedge. He concluded that the Rodman pressures should be taken to represent *mean,* not *maximum* pressures. By subjecting the discs and piston to the action of his pendulum, and dividing the kinetic energy or (work in foot-pounds) by the indentations (depths of cut expressed in feet), he obtained numbers which compared well with the pressures of the Rodman tables. On page 28 of his Report he gives a table of his results. In regard to this he

says: "The last two columns show a surprising correspondence between scales of absolute pressure obtained by methods so radically different as those of Rodman and my own. . . . The comparison of the two methods certainly tends to confirm the practical value of the Rodman scale, except, perhaps, for low pressures."

General Abbot's work certainly proves that for the double wedge cutter, or indenting tool, the Rodman pressures are practically equal to the *mean* resistances developed by a blow. This is an interesting and surprising result. In the compression of the cylinders we have seen that the Rodman pressures are directly proportional to the *maximum resistances* developed by a blow and bear no simple relation to the mean resistances. I have thought it worth while to make a comparison between the maximum resistances and the Rodman pressures for the double wedge cutter also.

Comparison of Dynamic Resistances and Rodman Pressures for the Pointed Cutter Piston or Indenting Tool.

For this purpose I use the data of General Abbot's table. I first plot a curve on a large scale using the work (W) expressed in foot-pounds as abscissas, and the computed indentations (I) expressed in $\frac{1}{1000}$ of a foot as ordinates. I then construct tangents to the curve at the extremities of the ordinates, and determine the tangents of the angles which these make with the axis of Y. These values of the tangents, multiplied by 1000, are the maximum resistances (or the resistances corresponding to the tabular indentations) expressed in pounds. As the accuracy of the results is a question of construction, I check the values of $\frac{R}{1000}$ thus obtained by plotting a new curve (R, I curve), using these values as the abscissas and the indentations as ordinates. From this new curve I take my final values of $\frac{R}{1000}$. I have checked these by practical integration of the R, I curve, as well as by comparison with successive differences in the value of the work. I therefore believe my results fairly accurate. Luckily, in this case, I can check them absolutely, though I must frankly admit thas this was an after thought. During the course of my work I noticed with interest that the W, I curve was evidently tangent to the axis of Y at the origin; also, that the the R, I curve passed through the origin. That is, the initial resistance is zero, which is reasonable, in view of the sharp point on the cutter. I

then began to cast around for an equation for the W, I curve, when I found it staring me in the face, General Abbot having already deduced it; in fact, he uses it to compute the indentations.

The equation is $I = .002156\,W^{\frac{1}{3}}$, whence $W = \frac{I^3}{.002156^3}$, in which W is the work in foot-pounds, and I is the path or indentation in feet.

If we let R equal the resistance in pounds,

we have $$W = \int R\,dI.$$

Differentiating, we have $$R = \frac{dW}{dI};$$

and applying this to the equation above,

$$R = \frac{3I^2}{.002156^3}.$$

From this, by substituting for I the tabular indentations, we can deduce the absolute values of the corresponding resistances.

I have concluded to let my values deduced by the graphic method appear in the table also, though the only purpose they serve is to show what accuracy can be expected by an unskilled draughtsman in using this method.

RODMAN TESTING MACHINE AND PENDULUM HAMMER.

Comparison of Pressure and Shock on Copper (Indenting Tool).

Kinetic energy of pendulum (W) work.	Copper indentations computed (I).	Rodman pressures (P).	Mean resistance $\left(\frac{W}{I}\right)$.	Max. resistance (R), graphic methods.	Max. resistance, $R = \frac{dW}{dI}$.	Ratio $\left(\frac{R}{P}\right)$
Foot-pounds.	Feet.	Pounds.	Pounds.	Pounds.	Pounds.	
0.226	.00131	285	172	490	514	1.8
0.630	.00184	533	340	970	1,013	1.9
2.496	.00292	1,180	855	2,550	2,552	2.16
5.532	.00380	1,880	1,451	4,350	4,323	2.3
9.743	.00460	2,584	2,116	6,200	6,334	2.45
14.860	.00530	3,315	2,803	8,200	8,409	2.54
21.290	.00597	4,040	3,566	10,300	10,669	2.64
28.930	.00662	4,867	4,371	12,950	13,119	2.69
37.370	.00721	5,660	5,186	15,500	15,561	2.75
46.800	.00777	6,463	6,025	18,000	18,072	2.79
57.000	.00830	7,280	6,872	20,600	20,622	2.83
67.980	.00880	8,110	7,725	23,500	23,181	2.86
79.610	.00927	8,890	8,590	26,300	25,724	2.89

The first four columns of the above table are taken from General Abbot. The other three columns are mine. The last column gives the ratio $\left(\frac{R}{P}\right)$ of the maximum dynamic resistances to the Rodman pressures. It will be noticed that this ratio is not constant, as in the case of the copper cylinders, but increases for the limits of the table from about 1.8 to 2.9 (see curves, Fig. 4, Plate III).

The table shows that General Abbot's point in regard to a substantial equality between the Rodman pressures and the *mean resistances* $\left(\frac{W}{I}\right)$ is well taken. We must regard this in the light of a coincidence which results from the form of the cutter. If we interpret these results by the light which we have already obtained on the subject, it appears that the resistance R developed by a blow is greater than the resistance P developed by pressure, and that the ratio $\left(\frac{R}{P}\right)$ between these quantities increases with the indentation. This results from the form of the cutter. The initial resistance is zero for both applications of force, so that this ratio must begin as an equality, or 1, and increase to its limiting value, which appears to be beyond the confines of the table.

In the cylinders, on the contrary, there is a well-defined initial resistance for both applications of force, and the ratio $\left(\frac{R}{P}\right)$ may and does hold a constant value from the beginning.

The form of indenting tool or Rodman cutter, now generally used, has a curved edge, usually the arc of a circle. I have no data at hand to determine its properties under the action of a blow or falling weight, but think it will develop a very small initial resistance. Otherwise its action will closely resemble that of the cutter used by General Abbot.

Application to Explosives.

It will be noticed that we have been careful so far to say as little about the intensity of the acting force as possible. We will now explain why.

From the standpoint of the artillerist, a given compression or indentation indicates that a certain pressure has been exerted, or a force has acted with a certain intensity. Having regard to the

whole field of explosives, we prefer to say that a certain amount of work has been done. A force has acted in producing this work, and the *final* intensity of this force is represented by the artillerist's pressure, or by our resistance, depending upon whether the force has acted slowly or quickly. In either case final intensity is the only intensity measured.

Case of Falling Weight or Impulsive Force.

The case of a disc indented or cylinder compressed by a blow or falling weight has some features of its own, and differs from the general case of work by an explosive; nevertheless, as it has been used to prepare our tables, we may get some light by discussing it.

What is the intensity of the force in this case? Evidently the measure we aim at is the intensity of the force at the moment of contact. This is strictly analogous to an explosive which delivers its blow in one impulse; but, as no explosive acts in this way, though the fulminates may proximate it, we see that we are dealing with a special problem. In the practical case of using the gauges to determine *the action of an explosive*, the record enables us to determine the *final* resistance of the copper only, which is equal to the final intensity of the force.

We know nothing of the intermediate history of the force from the beginning of its action to its close, except that its intensity at any intermediate point must have exceeded the corresponding copper resistance in order to overcome it. The law of variation in the intensity of the force during the time of action, so far as the record of the work discloses it, is a sealed book.

The work relates only to the *resistance* and the *path*. The intensity of the force may have been greater in the beginning, and diminished to an equality with the resistance which limited the path; it may have been constant throughout; or it may have increased during the period of action, but less rapidly than the resistance. The record on the copper furnishes us no data for determining the nature of the change. It gives the intensity at one point only, and even this must be obtained by an intelligent interpretation of the record.

In regard to the *mean intensity*, this, to my mind, is a conventional quantity that has no application as a measure of the force in

this case. To use it as such is to assume that the force is in equilibrio with the resistance at every point, and that its intensity is an average of the resistances; but we know that the intensity of the force must be greater than the resistance at every point except one, at which it is just equal to it. Mean intensity obtained by dividing the work by the path is, therefore, misleading, and bears no necessary relation to the force.

Returning to consider our special case, that of a falling weight, what is the intensity of the force corresponding to a given record? The measure we desire is the maximum intensity which coincides with the beginning of the action.

We know that the kinetic energy or work is equal to $\frac{1}{2}\frac{WV^2}{g} = Wh$, in which W is the weight of the falling body, V its velocity at the moment of impact, h the height of fall, and g the velocity impressed by the force of gravity in the unit of time. This energy is transferred to the piston or cutter, which is thus animated with a velocity that will cause it to describe a path shorter or longer, depending upon the resistance encountered.

The intensity of the force will diminish during the description of the path, and the path will end when the resistance encountered is equal to the diminished intensity of the force.

To throw further light on the subject I have prepared a new table comparing the final intensities of the force in the two cases of the indented discs and compressed cylinders for the *same work*. This table has been compiled from previous tables by graphic interpolations. The paths (indentations or compressions) are given in feet, also the mean resistances, obtained by dividing the work by the path. (See p. 567 for table.)

This table serves to show the relation between the three quantities, work, resistance, and path, for both cylinders and discs under the action of a falling weight. We can easily see by a study of this table that the only measure of the force is the work. Final intensity, as deduced from the record, is a *term related to previous resistances and the length of the path.* To illustrate:

1 foot-pound expended in indenting the copper disc shows a final intensity for the force of 1075 pounds.

1 foot-pound, in compressing the cylinder, shows also 1075 pounds final intensity, the ratio being 1:1.

60 foot-pounds on the disc shows a final intensity of 19,850 pounds. The same energy expended on the cylinder shows only 6300 pounds, the ratio being 3:1.

Nor does the mean intensity—work divided by the path—give more consistent figures.

1 foot-pound on the disc gives a mean intensity of 476 pounds.

1 foot-pound on the cylinder gives 860 pounds, the ratio being 1 : 1.8.

60 foot-pounds on the disc gives 7109 pounds mean intensity.

60 foot-pounds on the cylinder gives 3478 pounds, the ratio being 2 : 1.

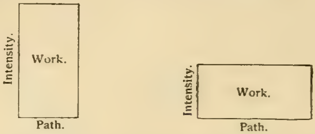
This shows that no reliable absolute figure for the intensity of the force can be obtained in this way, since by using a very high resistance and restricting the path the intensity can be indefinitely increased. The table, moreover, shows that no reliable *relative* figure can be obtained, for one column of resistances is just as reliable as the other, and they are inconsistent with each other.

Relation between Work, Resistance (Final Intensity), and Path. Compression and Indentation of Copper by a Falling Weight. (Rodman Pointed Cutter Used for Indentation.)

Work (W) foot-pounds.	Indentation of copper discs.		Compression of copper cylinders.		Discs.	Cylind'rs	Relative intensity $\sqrt{W} \times 1000$.
	Path.	Final intensity of force.	Path.	Final intensity of force.	Mean resistance.	Mean resistance.	
	Feet.	Pounds.	Feet.	Pounds.	Pounds.	Pounds.	Pounds.
0.1	.00100	250	.000132	770	100	760	316
0.2	.00125	450	.000258	780	160	776	447
1.0	.00210	1,075	.00116	1,075	476	860	1,000
2.0	.00271	2,100	.00198	1,400	738	1,010	1,414
5.0	.00365	4,100	.0036	2,000	1,370	1,390	2,236
10.0	.00463	6,560	.0058	2,610	2,160	1,724	3,163
20.0	.00587	10,360	.0089	3,630	3,407	2,247	4,472
30.0	.00672	13,500	.0114	4,280	4,464	2,631	5,477
40.0	.00748	16,270	.0136	4,900	5,348	2,941	6,325
50.0	.00794	18,540	.0156	5,490	6,297	3,205	7,071
60.0	.00844	19,850	.0173	6,300	7,109	3,478	7,746
70.0	.00889	23,650	.0187	7,160	7,874	3,743	8,367

The use of mean resistance to measure the intensity of a force and its dependence on the path may be illustrated by two diagrams

of work, equal rectangles, of which the vertical dimensions represent intensity, and the horizontal dimensions represent path, thus:



It may be asked, Is there any way of getting a measure for the intensity of the force?

I think a *relative figure* of some value may be obtained by extracting the *square root of the work.*

The falling body, striking with a velocity V, may be taken to represent a motive force. The intensity of a motive force is measured by the product of the mass moved by the velocity generated during the time of action divided by the time, the force being supposed constant during the time of action. If this time is very short this last condition is immaterial. The motion of the falling body is arrested by the resistance of the copper in an interval of time so short that it cannot be measured.

We can get a clear idea of the intensity of the force embodied in our falling weight at the instant of impact by supposing the action reversed. After the compression or indentation has been completed, let the original form and temperature of the copper be suddenly restored, so as to reverse the circumstances of the action and generate in the falling body the velocity of V in the same short interval of time, and throw the body to the height h. The intensity of the force exerted will be measured by $\frac{MV}{t}$, in which M is the mass, V the velocity of the falling body, and t the short interval of time.

Let us suppose this interval of time to be practically the same throughout the range of the experiments; this is rendered probable by the following considerations.

If the interval of time varies it will affect the resistance of the copper and, consequently, the recorded work.

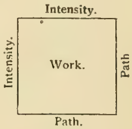
But it must be independent of the weight of the body, since we get the same record of work using different weights.

It is also independent of the height of fall, since we get the same record of work from different heights.

It follows that it is either independent of both, that is, constant, or exactly proportional to the work. But if it is proportional to the work, the formula $\frac{MV}{t}$ will give greater intensities for smaller velocities, which is absurd. The conclusion is that it is constant. Then the relative intensity will be measured by MV, and, since the mass is constant, by V, which is proportional to the square root of the work.

If this reasoning in regard to the interval of time t is unsatisfactory to the reader, then we fall back upon this simple consideration: The interval is so short that the force of restoration of the copper which will give the velocity V to the weight may be considered an *impulsive force*, the intensity of which, according to the mechanicians, is measured by MV—the quantity of motion generated during the *whole* time of action.

The use of the square root of the work to represent the intensity of the acting force is illustrated by a diagram of work, a square, in which either dimension may be considered intensity, and the other the path. In advocating the foregoing opinions, I am sorry that I do not agree on one important point with General Abbot, whose general views have had much to do with forming my own.



General Abbot regards the work registered by the gauge as the integral of the product of the force intensity into the differential of the path; consequently, he concludes that the mean pressure or intensity may be obtained by dividing the work by the path. He applies this alike to explosive mixtures and detonating compounds. It is true that he recognizes the arbitrary nature of his unit of intensity derived from copper indentations, and, moreover, shows that his final conclusions are independent of it. We also note his great need of an *absolute* unit of intensity, which he could obtain only by setting up an arbitrary test. Nevertheless, it is unfortunate that his table of intensities should be quoted as a classic by all writers on the subject, most of whom do not recognize the arbitrary nature of this unit. Perhaps it is unfair to hold General Abbot responsible for this.

While the available energy of the explosive (in the case of detonating compounds) is directly proportional to the charge, and

inversely proportional to the square of the distance (nearly), the intensity of action (mean pressure), *as a result of adopting this particular measure for it*, varies directly with the two-thirds power of the charge, and inversely with the 1.4 power of the distance.

If he had chosen to adopt the square root of the work as the relative intensity, the intensity of action would have varied as the square root of the charge, and inversely as the distance.

The point in which we differ is this: he regards force intensities as being in equilibrio with resistances. From one point of view he may be right. There are often two ways of looking at a question in mechanics; both may be right, but one may be objectionable on account of the train of consequences.

It is quite usual to speak of work as the product of the effort into the path (see Bartlett's Synthetical Mechanics, page 49), or the product of a force intensity into a path; but, strictly speaking, it is better to regard work as the product of a *resistance* and a path. The habit of regarding resistance and force intensity as equivalents is drawn, I think, from Watt's diagram of work, in which a curve limits the ordinates representing the varying pressures of a gas. The external work done by the gas is the area included between the axis of abscissas, the curve, and the extreme ordinates. But the fundamental condition is that all parts of the gas shall be at the same pressure (see Tait's Thermodynamics, page 87), which is equivalent to saying that it is in equilibrio throughout, and, consequently, in equilibrio with the resistance.

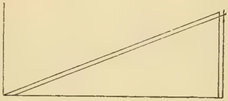
In the general case, the force intensity is not in equilibro with the resistance when performing work. To consider it so is to attach no useful meaning to the term intensity. In the case of work on the copper cylinders or discs, to consider it so gives the force its greatest intensity at the moment it ceases to work.

A weight falling from a certain height represents a certain force, the intensity of which should be a property of the force itself. But if the force be allowed to work we can get any intensity we please by this rule. By extending the path we reduce the intensity; by limiting the path we can increase it indefinitely. But, if force intensities are sometimes in equilibrio with resistances and sometimes not, where do we draw the line? It is true that forces are always in equilibrio; that is, we can find for every acting force a counterpart equal and contrary in direction. But to do this for every case, we

must sometimes consider inertia. When inertia is not considered, that is, when the motion is so slow that we may neglect it, or when the work of inertia is balanced by minus and plus work, we can safely deduce the work of the acting force from the force intensity and the path; or, reversing the operation, deduce the intensity from the work and path.

We have elsewhere said that a force intensity must always exceed a resistance to overcome it. How then, in *any case*, can the integral of the product of the force intensity into the differential of the path give the same result as the integral of the product of the resistance into the same differential?

Mechanics is filled with just such paradoxes. The difference in this case between force intensity and resistance is very slight and is not cumulative. The paradox may be illustrated by the following diagram, in which two equal triangles, almost exactly superposed, represent—one the work as deduced from the intensity, the other from the resistance.



To show what forces are in equilibrio during the compression or indentation of the copper by a falling weight, let us resume our hypothesis that, at the instant of maximum work, a force of restoration reproduces the original form and temperature of the copper, exactly reversing the circumstances of the direct action. Let us suppose the path to be divided into a number of elementary paths corresponding to a series of elementary times.

The force of restoration, now the acting force, will have an initial intensity or pressure equal to the final copper resistance in the direct action. This intensity corresponds to the first elementary time, and would, if it remained constant, generate in the body in the unit of time a quantity of motion equal to itself. The acting force will be in equilibrio with the force of inertia. During the next elementary time the force will have a slightly less intensity, which would generate in the unit of time an equal quantity of motion. The force of inertia again opposes an equal and contrary reaction, and so on, through all the elementary times.

Now let the elementary path be ds, and the elementary time dt.

The intensity of the force at any point will generate a velocity V, which may be regarded as constant during the elementary time dt,

during which the body will describe uniformly the elementary path *ds*. Hence we have

$$V = \frac{ds}{dt}, \text{ or } ds = Vdt; \tag{1}$$

The intensity of a motive force, or the inertia it will develop, is measured by the quantity of motion which it can generate in the unit of time, the intensity remaining constant for that time. The intensity of the force will vary, in this case becoming less and less. However, we may regard it as constant during the elementary time *dt*, during which it generates a velocity *dV*, and were it to remain constant it would generate in the unit of time a velocity $\frac{dV}{dt}$.

Denoting the varying intensity by *R*, we have, therefore,

$$R = \frac{MdV}{dt}, \tag{2}$$

or,

$$R = M\frac{d^2s}{dt^2},$$

that is, the intensity of the acting force, or the inertia which it develops, is equal to the product of the mass moved into the velocity impressed in the unit of time, or more simply, the mass into the *acceleration.*

Multiplying equations (1) and (2) together, we have

$$Rds = MVdV, \tag{3}$$

from which, by integration, we get

$$\int Rds = \frac{MV^2}{2}.$$

The first number is the work of the force equal to that of the inertia; the second, the kinetic energy of the body as a result of this work.

Returning to the direct case of compression or indentation by the falling body, we see that the copper resistance at every point is in equilibrio with the *successive decrements* in the quantity of motion of the body; or, what is the same thing, it is in equilibrio with the inertia developed. We now see the sense in which the force intensity and the resistance may be considered in equilibrio, the point of view which General Abbot adopts. *It is that portion of the intensity which is called into play to overcome the resistance.* The intensity

not called into play for the time being *may* be considered as pertaining to *potential* energy.

The foregoing demonstration, if it may be considered such, has not the slightest claim to originality. It is taken almost bodily from that grand old book, Bartlett's Analytical Mechanics.

Strength of Explosives.

We make a short digression to consider a subject which has engaged the attention of many practical men. *What is the proper measure of the strength of an explosive?*

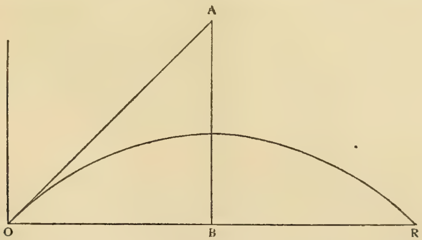
For commercial purposes there can be but one answer. Strength in this sense is a question of dollars and cents. When the miner buys dynamite he buys power; that is, something capable of doing work.

The proper measure is one which makes two pounds of the explosive twice as strong as one pound.

Let us see whether this is the compression of a lead or copper cylinder, intensity (mean or final), velocity given to a shot, or what not.

We will first consider the mortar or éprouvette, a very short gun, fixed at an angle of elevation of 45°, and throwing a heavy shot short distances, usually less than 1000 feet.

It was long ago observed that two ounces of gunpowder gave twice the range of one ounce. The rule holds with even greater exactness in the case of dynamite or other high explosive. The range is, there-



fore, the proper measure. The range being short and the shot heavy, atmospheric resistance may be neglected, and the trajectory be considered a parabola.

The height h, due to the initial velocity V, is equal to AB, but the angle of projection being 45°, OR, the range, is equal to twice AB, hence $V = \sqrt{2hg} = \sqrt{Rg}$, R being range or $V^2 = Rg$; hence the work $\frac{1}{2} MV^2 = W. \frac{1}{2} R$, in which M is the mass and W the weight of the shot. From which we see that the range is proportional to the work.

The only other measure we can consider in this case is the *intensity* of the force of projection, which is measured by the product of the mass moved into the velocity generated during the time of action divided by the time. The force is assumed to be constant during its action, and the time we can only guess at. The best we can do is to assume the intensity to be measured by the product of the shot's mass by the initial velocity, or MV, which is equal to $M\sqrt{Rg}$. This measure is based upon the velocity imparted to the shot; the other on the square of this velocity. It is needless to say that the latter measure is right and the other wrong.

To confirm our assertions we could give numerous examples of mortar experiments taken from my note books, but we trust the reader will take our word for the fact that, deducting the range due to the cap, the range of dynamite or other high explosive is very exactly proportional to the charge.

In a similar way we could show by notes of actual experiments that the work of a high explosive in the crusher gauge, as deduced from our curves, is likewise proportional to the charge. In fact, so accurate is this principle that it may be used to check a new curve or extend an old one.

We, therefore, think that the *strength of an explosive should be considered as measured by its available energy, or the work it is capable of doing under some test capable of measurement.*

In this we are not laying down any new principle, but one which has sometimes been ignored. General Abbot, however, gives it full recognition.

Application to High Explosives.

So far our discussions have been chiefly concerned with the test of explosives which are too quick in their action to have the Rodman method applied to them. We can sum up this part of our subject as follows: When the crusher or cutter gauge is used, the work and its elements, path and resistance, must be measured by a *dynamic* scale;

that is, a scale determined by the sudden application of a force. The only method so far adopted for preparing such a scale is that of the pendulum or falling weight.

This application of force develops the highest form of copper or lead resistance; consequently, a given compression or indentation will denote a greater work than the same compression or indentation by the Rodman scale, in which the low form of copper or lead resistance figures. We have shown that in crushing the copper cylinders (.25″ × .50″), by the two methods (measure and shock), these two resistances bear nearly a constant ratio of 1 : 1.3.

In the indentation of copper discs by the pointed cutter, the ratio between the low and high form of resistance increases with the path from about 1.8 to 2.9 for the limits of our data.

The ratio of these two forms of resistance, in the case of *lead*, is much larger than in copper, as shown by General Abbot; indeed lead resistance is so sensitive to change in this regard that General Abbot found it difficult, if not impossible, to establish a satisfactory Rodman scale of pressures for it.

We can say, therefore, that *lead is only suited to the dynamic scale.*

Now, keeping in mind this fact of a change in the nature of lead or copper resistance depending upon the time consumed in the application of the force, we see that the *actual* work done by an explosive may not be the same as the work or kinetic energy of the falling weight, set down in our tables as corresponding to the compression or indentation, because the explosive may be slow enough to develop a lower resistance than that encountered by the falling weight.

The error is liable to be much larger with lead than with copper, and so far as this argument goes, copper is the better of the two materials, and the cylinders better than the discs; since, in the cylinders, the extreme variation in the resistance is only from 1 to 1.3. We can usually determine from outside considerations whether the explosive is liable to excite some intermediate form of resistance.

We had in the experiments with the water crusher gauge a striking example of the effect of *prolonged action* of the explosive upon lead; but this was the result of an accident, the gauge no longer acting as such but as a mortar. In testing explosives the senstitive nature of lead resistance renders it essential that there should be an instant release of the gases, which is secured by the construction of both the

Drinker and Quinan gauges, otherwise the dynamic scale would not apply.

Practical observation in testing explosives, both with the crusher gauge and mortar, has given rise to a belief, which may be stated as a paradox, though it hardly rises to the dignity of a scientific fact. It is this: Among slow explosives, or explosive mixtures, the one that makes the best "showing" is the quickest one. Among quick explosives, or detonating compounds, the one that makes the best "showing" is the slowest one.

Taking this rough statement for what it is worth, it is not without reason to support it. To overcome a given resistance and perform work, a certain intensity or rapidity of action is necessary, but if the action is more rapid than necessary it creates difficulties for itself.

If two detonating explosives are equal in chemical attributes, I think the slower of the two will make the best record; that is, give the greatest compression in the crusher gauge. They may have *actually* performed the same work, but the quicker one will encounter a higher resistance and give less compression, consequently. In such a case the question could be decided by measuring the heat developed in the plugs, practically a difficult matter.

By chemical theory the advantage of blasting gelatine over nitro-glycerin is very slight, but it makes a decidedly better "showing" in the gauge. I think it is very slow as a detonating explosive, but have no absolute method of proving it. The question whether or not the "showing" in the crusher gauge, as dependent on the relative slowness or quickness of high explosives, represents a real advantage in certain blasting operations, would depend upon the law of change in the particular resistance encountered. If, like copper and lead resistance, it increased with rapidity of action, the advantage would be real. If, on the contrary, it decreased with rapidity of action, the advantage would be unreal. Where a large part of the work consists in moving heavy masses of material, the advantage would be real, as inertia is a resistance which increases with rapidity of action. Where, on the contrary, the breaking of hard rock constituted the chief element of the work, I think the advantage would be unreal.

To illustrate, it has been found that for breaking boulders by surface action, blasting gelatine is inferior to dynamite, being, as I take it, too slow for the work.

Crusher and Cutter Gauges in Guns.

The question at issue here is whether the record of the gauge is to be interpreted as a record of work or a record of pressure.

According to the artillerist, it is a record of maximum pressure. When the record is made in the testing machine it may be considered indifferently a record of either work or pressure.

Let us first consider this operation. The motion of the point of application of the force is so slow that inertia may be neglected, and the pressure and resistance be considered equal. The force develops the low form of copper resistance. Even if we attempt to apply the force suddenly and develop a higher form of resistance, this passes into the low form before we can measure it, the copper yielding enough to establish an equality between the pressure and the low form of resistance. The work is, therefore, the integral of the product of the varying pressure into the differential of the path.

The argument that the gauge record is a record of the highest pressure in the gun is this: a certain path corresponds to a certain maximum pressure, because any pressure less than this will not overcome the resistance up to this point, and any pressure greater than this will overcome the resistance beyond this point, and so extend the path. This reasoning assumes that the action of the powder gases is substantially like that of the testing machine.

In regard to the action of powder in guns, the celebrated English Committee on Explosives said something as follows. I quote from memory, and if the Committee did not say the equivalent of this I will father it myself.

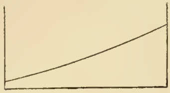
"When a charge is lighted in a gun the pressure rises rapidly to a point a little below the maximum, then more slowly to the maximum at which epoch the shot has just moved. The pressure then falls more or less rapidly, depending upon various circumstances."

We will assume, for the sake of argument, that the time required to give a certain compression or indentation in the testing machine and the time of action of the powder gases in the gun are equal.

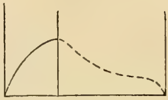
The Rodman theory of the crusher gauge may be illustrated by two rough diagrams, one of which represents the action of the testing machine, the other the action of the powder gases (page 578).

The ordinates represent pressures, the abscissas, times. Neither is a diagram of work; both are diagrams of pressure as related to

time. The powder pressure is only effective in making the record during its passage from zero to maximum, consequently the latter part of the powder curve is dotted.



Testing Machine.



Powder Gases.

The diagrams for the cutter gauge present no differences from the above which make it worth while to specially consider them.

We think this presents the Rodman view very fairly. The argument is plausible. Moreover, it is supported by General Rodman's experiments, also by the English experiments, before alluded to, in which a copper cylinder, compressed by a charge of powder, was used over and over again for the same test without undergoing further shortening.

When I started this discussion I stated my belief that the record of the Rodman gauge was a record of work. That was prejudging the case, but that belief, like any other I may hold, is subject to correction. General Abbot, who is an advocate for work also, makes in this connection a very shrewd remark. He asks: "Why should further motion be communicated to the indenting tool when supported by a surface cut in the copper, which has resulted not only from the maximum action, but from the combined effect of all other actions?"

Having presented the argument for pressure, perhaps the fairest way is to present as strongly as possible the argument for work, reconciling the two views as best we may. We have already seen that working forces present two distinct cases.

The first is the case of a force working so slowly that inertia is not concerned—the resistance it develops at any instant is practically in equilibrio with it. I say practically because the equality is only approximate. If there is absolute equality at any instant the work ceases. This is the case of work in the testing machine. Its characteristic is the absence of kinetic energy. The work is an incidental. The record is a record of pressure.

The second case is that of a dynamic force proper, which is typified by a body moving with a certain velocity and possessing a kinetic energy depending upon this velocity and the body's mass—

that is, it is capable of doing a certain amount of work, and, moreover, it *must* do that amount of work and no other.

Now, the pressure of the powder gases is a static force so long as it does no work, or works so slowly that there is a continuous practical equality between pressure and copper resistance, but it *may* be transformed into kinetic energy by giving motion to the piston.

In the general case, is this force applied gradually as in the testing machine, or do the gases launch themselves against the piston and drive it into or against the copper?

Assuming the circumstances of the action to be given correctly by the latter statement, at or near the beginning of the motion, the powder pressure in running up to its maximum exceeds the corresponding copper resistance. Having received its maximum it will fall more or less rapidly, but the piston will continue to move, notwithstanding that the resistance may then exceed the powder pressure. The energy in excess at the beginning fills the deficiency in the latter part of the path.

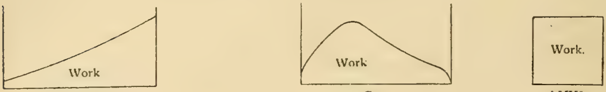
In the testing machine, when the pressure falls below the resistance, the piston comes to rest. Why does it continue to move under the action of the powder gases? Because the force is now kinetic. The energy is stored in the piston by virtue of its inertia, and is given out as required to overcome the resistance till its allotted task is finished.

The attentive reader may say this is the same case as that of work by a falling weight. It is something like it, but there is a radical difference. In one case the force begins as a maximum, as a completed force, and receives no accession during the path. It acts with one impulse. In the other case, that of powder in the gun, the force begins to act on the copper with a very low intensity (determined by the initial resistance of the copper) and receives continual accession throughout the path. In one case the force is impulsive; in the other it is varying and incessant. Moreover, in the first case the path is described in an instant; in the other probably in some fraction of a second. The first is quick compared with anything; the latter is quick compared with some things and slow compared with others. The first action develops the highest limit of copper resistance; the second is prolonged enough to allow this resistance, even if it is developed, to pass into the lower form.

To show the futility of attempting to obtain the pressure from the

work in the case we have been considering, let us construct the crusher diagrams of action (now representing work) for the testing machine and the gun once more.

DIAGRAMS FOR CRUSHER GAUGE.

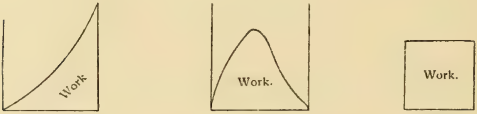


1. Testing Machine 2. Gun $\frac{1}{2}MV^2$.

Let the ordinates represent pressures or intensities, and the abscissas paths. The area of the first diagram is the work done in the testing machine. The path being the same in the two diagrams, if we know the form of the curve in the second diagram, we can deduce the varying intensities of the force which, as ordinates, will give the same area or work. But can we consider these intensities powder pressures?

Unfortunately for the hypothesis we cannot, for if we shorten the path, as in the following diagrams for the cutter gauge, the powder

DIAGRAMS FOR THE CUTTER GAUGE.



Testing Machine 2. Gun. $\frac{1}{2}MV^2$

charge and, therefore, the work, being the same, we must reckon a higher intensity for the gun diagram, although the action of the gases in the gun must have been the same.

We see, therefore, that when the record in the gun is to be interpreted as *work* there is no way of obtaining the *absolute* intensity of the force, as represented by pressure in the bore. The only safe relative measure then for the force is the square root of the work.

Our next purpose is to show that the distinction between interpreting the gun record as work and interpreting it as pressure is radical, and that it is necessary in any given case to choose between them.

By putting in the bore of the gun either a cutter or crusher gauge, or both, we cannot alter the circumstances of the powder action. If the record is one of work, the work shown by the two gauges will be the same; if it is a record of pressure, the pressure shown by the two will be the same. I propose to show that generally, if the pressures agree, the works will disagree, and *vice versa*.

My first step has been to prepare certain tables showing the relation between work, pressure and path, as deduced from the action of the testing machine for both cutter and crusher gauge. These have been prepared from the data of the Rodman tables and the corresponding curves which give the relation between pressure and path. By integration of the area corresponding to a given path (that is, the area between the curve, axis of paths, and extreme co-ordinate representing the pressure), I first constructed tables of the work corresponding to a series of paths for both instruments, then curves showing this relation, from which curves I could obtain the interpolations more readily. From these curves (see Plate IV, Fig. 3, in which they are plotted on a small scale) I took the required data.

My original data consisted of the Rodman scale of pressures for the crusher, prepared at Frankford Arsenal, and the Rodman scale of pressures for the double wedge or pointed cutter used by General Abbot.

It was my intention to include in the scope of my work the *curved cutter*, now generally used by the Ordnance Department, and I did a good deal of work in this direction before I became convinced that my data was insufficient for the purpose. The cutter was obtained from the National Armory, being part of the equipment of a new .30 calibre rifle for testing smokeless powders. The edge of the cutter was the arc of a circle 3 inches in diameter, the cutting angle being 60° and the piston $\frac{1}{30}$ square inch in cross section. I received a scale of pressures with the cutter extending from 20,000 pounds to 79,000 pounds on the square inch, corresponding to *lengths* of cuts from .498 to .806 inches. I computed the paths, that is, indentations, from a table of natural sines and reduced them to feet, the corresponding pressures being divided by 30, and found my extreme pressures 667 and 2633 pounds, and my extreme paths .00173 and .00460 feet. This left a wide gap near the origin of the curve I desired to plot.

I attempted to fill this gap, and at the same time determine the initial resistance by placing weights on the piston without shock and determining the corresponding indentations in copper. The copper used was the kind recommended by the Springfield authorities, obtained from Moffet, of New York. I got *four* satisfactory interpolations in this way, and concluded that the initial resistance was very small, probably about 10 pounds.

However, when I came to plot the curve I found the armory data gave me nearly a straight line (curving slightly the wrong way), which offered no promise of reaching the origin without a violent change of direction; instead it pointed to a large negative resistance at the origin. I therefore concluded that this scale had not been determined in the usual testing machine, and reluctantly gave up the task of going further with the matter. The following is an abridged table of the data used in plotting the unfinished curve, which will be found on Plate IV, Fig. 2. The first four items in the table are mine. The rest were computed from the Springfield scale of pressures.

Relation Between Pressure and Path. Curved Rodman Cutter $\frac{1}{30}''$ Piston. Edge Arc of 3″ Circle. Most of Data from Scale of Pressures Prepared at the National Armory, April, 1891.

Length cut (inches).	Path depth of cut (feet).	Pressure (pounds).	
.028	.000005	13	These data were obtained by placing weights on the piston without shock, the cutter edge resting on copper.
.068	.00003	17	
.131	.00012	41	
.298	.00062	313	
.498	.00173	667	Armory data.
.522	.00191	800	
.546	.00209	933	
.570	.00228	1,067	
.615	.00266	1,333	
.658	.00304	1,600	
.699	.00344	1,867	
.738	.00384	2,133	
.775	.00424	2,400	
.806	.00460	2,633	

For the sake of convenience in studying the subject, I have arranged the data relating to work, pressure and path for the crusher and pointed cutter gauges into three tables. The first is arranged with reference to work, the second with reference to pressure, the third with reference to path.

A cursory examination of these tables shows (see also curves on Plate IV, Fig. 3):

1. Work being the same
   - Pressure.
     Cutter $>$ crusher, except for very small work.
   - Path.
     Crusher $>$ cutter, except for moderate and small work.

2. Pressure being the same
   - Work.
     Crusher $>$ cutter.
   - Path.
     Crusher $>$ cutter, except for very small pressures.

3. Path being the same
   - Work.
     Cutter $>$ crusher, except for very small paths.
   - Pressure.
     Cutter $>$ crusher, except for small paths.

Relations of Work, Pressure and Path. Crusher and Cutter Gauges in Rodman Testing Machine. Arranged for Work.

	Pressure (pounds).		Path (feet).	
Work (Foot-pounds).	Crusher (cylinders).	Cutter (pointed) (discs).	Crusher (cylinders).	Cutter (discs).
0.1	550	230	.00019	.0010
0.5	699	630	.00082	.00195
1	863	965	.00146	.00260
2	1,151	1,560	.00241	.00343
3	1,370	1,940	.00319	.00399
4	1,564	2,400	.00387	.00447
5	1,716	2,740	.00448	.00486
6	1,865	3,100	.00504	.00520
8	2,103	3,660	.00605	.00580
10	2,313	4,300	.00696	.00630
12	2,514	4,830	.00779	.00674

Work (Foot-pounds).	Pressure (pounds). Crusher (cylinders).	Cutter (pointed) (discs).	Path (feet). Crusher (cylinders).	Cutter (discs).
14	2,680	5,300	.00856	.00713
16	2,845	5,780	.00929	.00748
18	2,975	6,250	.00990	.00780
20	3,115	6,700	.0106	.00865
25	3,434	8,000	.0121	.00870
27	3,545	8,640	.0127	.00895
30	3,745		.0135	
35	4,020		.0148	
40	4,320		.0160	
45	4,585		.0171	
50	4,854		.0183	
55	5,134		.0192	

Relations of Work, Pressure and Path. Crusher and Cutter Gauges Treated in Rodman Testing Machine. Arranged for Pressure.

Pressure (pounds).	Work (foot-pounds). Crusher (cylinders.)	Cutter (discs).	Path (feet). Crusher (cylinders).	Cutter (discs).	
1,000	1.3	1.05	.0017	.0027	
2,000	7.0	3.20	.0056	.0040	
3,000	18.1	5.75	.0101	.0051	
4,000	34.7	9.00	.0147	.0061	
5,000	52.6	12.80	.0186	.0069	
6,000	70.5 (?)	16.80	.0216 (?)	.0076	(?) Doubtful, be-
7,000		21.00		.0082	yond the limits
8,000		25.00		.0087	of the curves.
9,000		28.10		.0091	

Relations of Work, Pressure and Path. Crusher and Cutter Gauges in Rodman Testing Machine. Arranged for Path.

Path ($\frac{1}{1000}$ feet.)	Pressure (pounds). Crusher (on cylinders).	Cutter (on discs).	Work (foot-pounds). Crusher (cylinders).	Cutter (discs).
1	800	235	0.75	0.106
2	1,050	650	1.7	0.53
3	1,320	1,250	2.7	1.47
4	1,580	1,950	4.2	3.07
5	1,845	2,900	5.8	5.49
6	2,070	3,940	7.7	8.90
7	2,313	5,120	10.0	13.43
8	2,540	6,640	12.2	19.80
9	2,760	8,800	14.9	27.47
10	2,975		18.0	
12	3,400		24.5	
15	4,060		35.5	
20	5,360		59.5	

The tables and curves have involved considerable labor, but they may serve to help some student of the subject. We can show their utility by a practical case. Suppose both cutter and crusher gauges to be used in a gun, and that the path (compression) for the crusher is .0060 feet, for the cutter (indentation) .0041 feet. The corresponding pressures are 2,070 and 2,050 pounds. The corresponding works are 7.7 and 3.25 foot-pounds. In this case the record would be one of pressure since the pressures are practically equal, while the work for the crusher is more than double that for the cutter.

But suppose the path for the crusher to be .00448, while that for the cutter is .00486 feet. The corresponding pressures will be 1,716 and 2,740 pounds, while the work will be 5 foot-pounds for each. The record in such a case is a record of work since the pressures disagree.

This would make the question one of fact, to be determined by a comparison of the records of the two instruments, and when we can bring a question to this satisfactory state there is little room left for argument. We may make some effort, however, to reconcile the two views of the question which we have tried to present fairly and which we now see are incompatible in any particular case. If one is right, the other is wrong. The fact is, we know very little about the action of powder gases. Both views rest upon simple but contrary hypotheses in regard to this action—one that the powder acts so slowly that pressures and resistances are virtually in equilibrio, the other supposes this action to be quick enough to be converted into kinetic energy. In the first case no kinetic energy is developed—the record is pressure. In the second case the energy is entirely kinetic, and the record is work.

Now gunpowder covers a great range of sizes of grain. Between grains 1.5 inches in diameter and fine grained rifle powder there is an immense gap. The time of burning may be taken directly proportional to the diameter of the grains, perhaps giving a ratio of 100 : 1 in the times of action for the two cases. Time of action determines whether the powder gases will act as a pressure or kinetically. It is possible, therefore, that one view is applicable to the coarse powder and the other to the fine.

The only suggestion of value I have to offer as an outcome of the study given to the subject is this: *by using two gauges presenting*

different resistances, the question in regard to the interpretation of the record becomes one of fact to be determined by a comparison of the two records.

All then that is required to solve the question generally is certain data of this nature, data which I unfortunately lack.

For slow-burning powders I have no doubt that the Rodman principle is reliable. This was the case it was designed to meet. I have too much admiration for this original thinker, as well as respect for the accomplished corps of officers who have followed in his footsteps, to lightly criticise his work, even if I thought there was a chance to do so, but I wish to state my belief that the Rodman principle is perfectly reliable for the cases to which he intended it to be applied.

But I do not believe that the Rodman gauge can be used to determine the pressures of fine-grained quick powders in small arms. I regret that I cannot support this by experimental data as I had hoped to do in time for this paper.

Whether or not the record in such a case is a reliable one of work would depend upon whether or not the *whole* energy of the powder acts kinetically.

It is hard to conceive that there should be an exact point at which the record ceases to be a pressure and becomes work, in fact, impossible.

It would seem from this that there may be such a thing as a mixed action.

We have always, however, our criterion—the agreement or disagreement of the two gauges. If they agree upon pressure, the record is pressure. If they agree upon work, the record is work. If they agree in neither, then there has been a mixed action, and a comparison gives either one or the other predominence. It is evident, I think, that a valuable study of the particular powder may be made in this way, and a good idea may be formed of its mode of action in the gun.

Professor Bartlett suggested in his original criticism of General Rodman's scheme the use of a series of measured initial resistances of different intensities as a substitute for the Rodman gauge. The English experimenters in using a cylinder already compressed virtually applied this principle. The compression not being increased, they assumed very properly that the pressure did not exceed the

figure corresponding to the first compression. But this was a typical case of slow-acting powder giving a record of pressure.

Does this prearranged initial resistance, approximating the final resistance developed by the powder action, present any special advantage in gauging quick powders? It may be said, in its favor, that the force cannot act kinetically unless it can overcome the initial resistance, but it can also be said *per contra* that if it *does* act kinetically it *will* overcome the resistance, as illustrated by my experiments in the foot-pounds machine. It may be remembered that I took copper cylinders very highly compressed and dropped the weight on them from very minute heights, in every case getting a record of work.

It does not seem to me, therefore, that this plan entirely overcomes the difficulty of obtaining an absolute figure for the pressure, when the record made in the ordinary way would be an unequivocal record of work. It simply shortens the path and shows a corresponding high intensity of action, when a longer path, as in the ordinary case, would show a less intensity. The difficulty would be this: as the force is certain to act, the higher the initial resistance is set the higher the pressure that would be credited to the powder.

In mixed actions, however, this plan might serve a good purpose in determining the mode in which the powder would act. The piston would have no chance to acquire living force by moving over a comparatively unguarded path. I think, therefore, that in the general case of quick powders an initial resistance would be useful in converting a doubtful record into a record of pressure. However, the conclusions in such a case should be checked by using two different instruments.

It is possible that no explosive used in fire arms is capable of writing a record of work which will agree in two such different instruments as the cutter and crusher gauges. This we cannot settle positively, but think that the fine grained smokeless powders proposed for small bore rifles may do so. In dealing with these agents we are really dealing with high explosives, although under a new form possessing new properties. The condition required for explosion is analogous to the condition for detonation—pressure for one and shock for the other. Smokeless powders are feeble or strong in proportion to the initial pressure which causes explosion. In gunpowder the burning is progressive, and the velocity of combustion

is independent of the pressure. In smokeless powder the burning is, or should be, progressive, but the velocity of combustion is directly dependent on the pressure. Between conditions which will not cause it to burn at all, and conditions which will cause it to explode violently, the step is very short. Finally it differs from gunpowder in this: the gunpowder reaction is external between molecules, the smokeless powder reaction is internal between atoms in the same molecule. These differences would seem to show that caution should be exercised in applying the same tests to the two explosives. In suggesting the use of the two gauges, we think we have indicated a method of working which will throw light upon the action of the newer agent.

I.

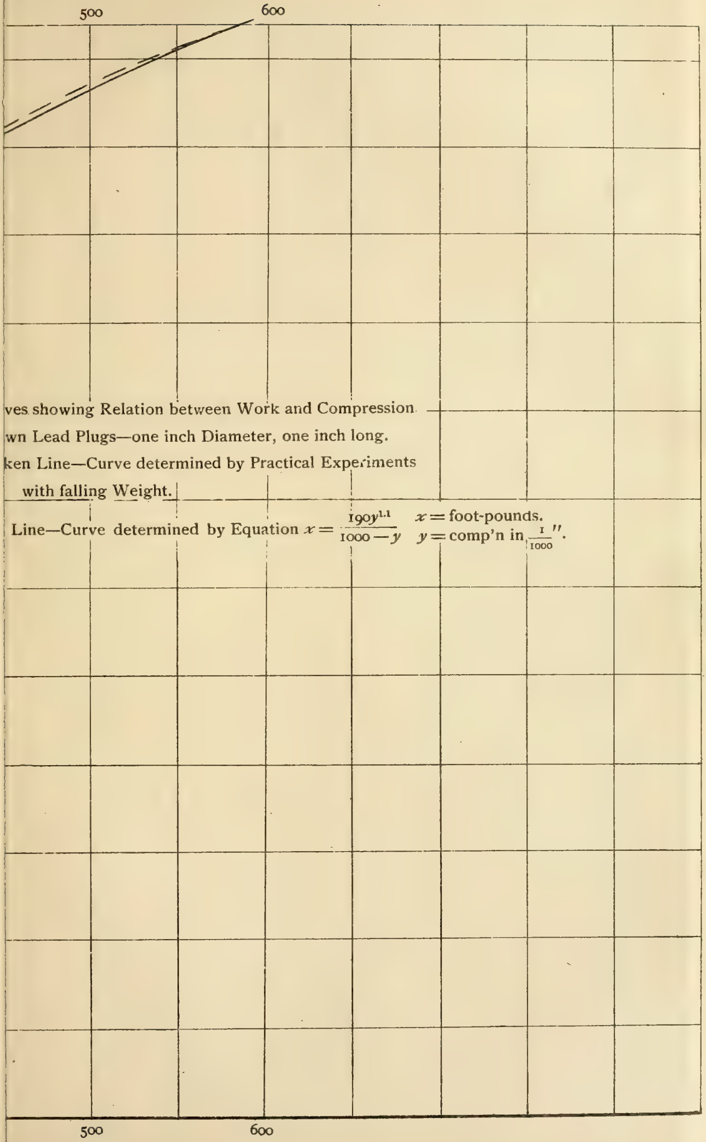

500
600
ves showing Relation between Work and Compression
wn Lead Plugs—one inch Diameter, one inch long.
ken Line—Curve determined by Practical Experiments with falling Weight.
Line—Curve determined by Equation $x = \frac{190y^{1.1}}{1000 - y}$ x = foot-pounds. y = comp'n in $\frac{1}{1000}''$.
500
600

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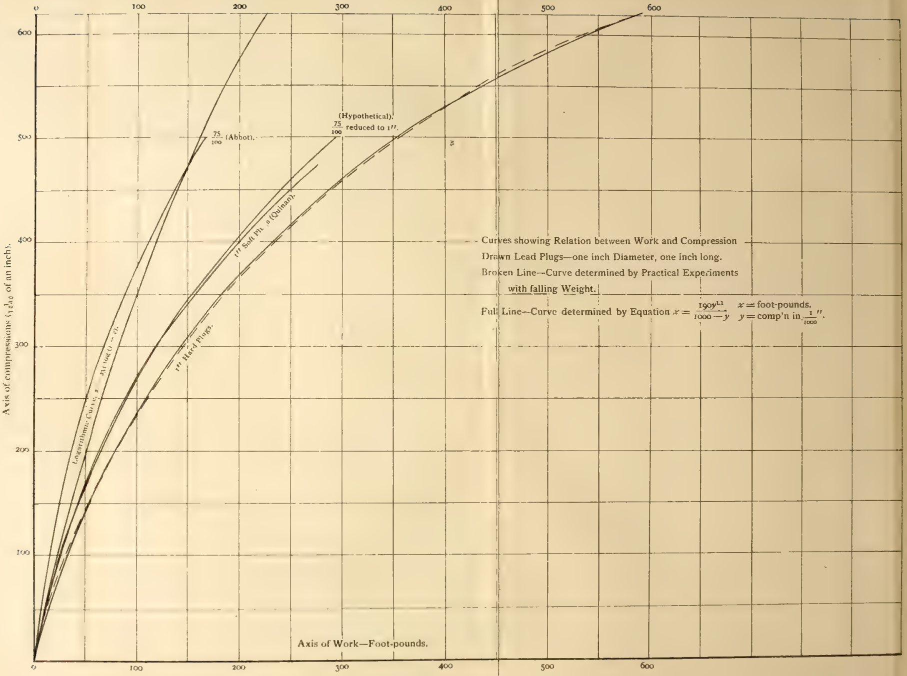
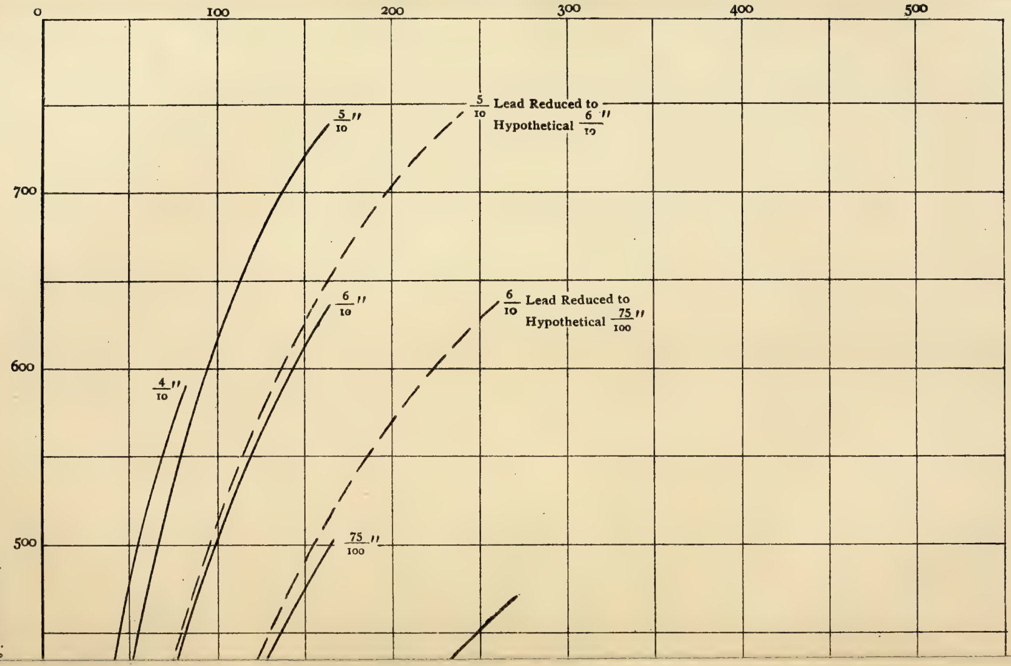
PLATE I.



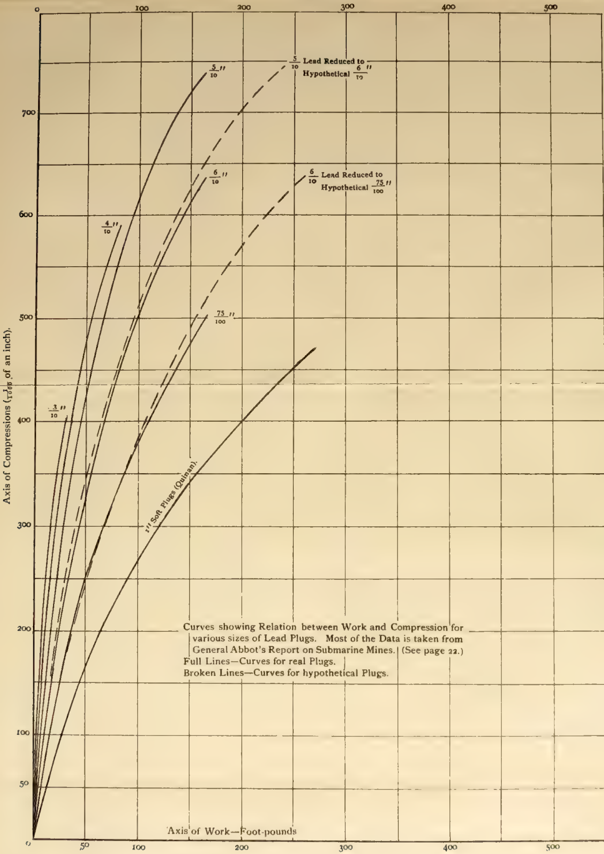
Curves showing Relation between Work and Compression
Drawn Lead Plugs—one inch Diameter, one inch long.
Broken Line—Curve determined by Practical Experiments with falling Weight.
Full Line—Curve determined by Equation $x = \frac{190y^{1.1}}{1000-y}$ $x =$ foot-pounds. $y =$ comp'n in $\frac{1}{1000}$″.
Axis of Work—Foot-pounds.
Axis of compressions ($\frac{1}{1000}$ of an inch).
$\frac{75}{100}$ (Abbot).
(Hypothetical). $\frac{75}{100}$ reduced to 1″.
1″ Soft Plugs (Quinan).
1″ Hard Plugs.
Logarithmic Curve
0
100
200
300
400
500
600

PLATE II.



0
100
200
300
400
500
700
600
500
4/10″
5/10″
6/10″
75/100″
5/10 Lead Reduced to Hypothetical 6/10″
6/10 Lead Reduced to Hypothetical 75/100″
of an inch).

PLATE II.


Axis of Compressions ($\frac{1}{1000}$ of an inch).
Axis of Work—Foot-pounds
0
100
200
300
400
500
50
600
700
$\frac{3}{10}$″
$\frac{4}{10}$″
$\frac{5}{10}$″
$\frac{6}{10}$″
$\frac{75}{100}$″
$\frac{5}{10}$ Lead Reduced to Hypothetical $\frac{6}{10}$″
$\frac{6}{10}$ Lead Reduced to Hypothetical $\frac{75}{100}$″
1″ Soft Plugs (Quinan).
Curves showing Relation between Work and Compression for various sizes of Lead Plugs. Most of the Data is taken from General Abbot's Report on Submarine Mines. (See page 22.)
Full Lines—Curves for real Plugs.
Broken Lines—Curves for hypothetical Plugs.

I.

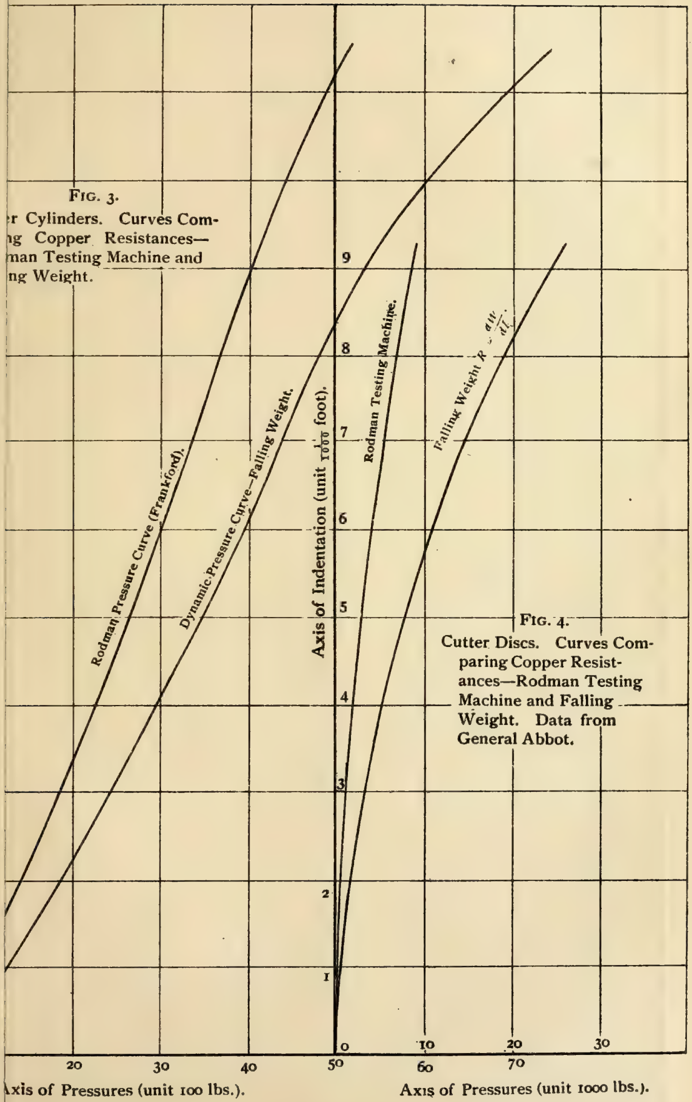


FIG. 3.
r Cylinders. Curves Com-
ng Copper Resistances—
man Testing Machine and
ng Weight.

FIG. 4.
Cutter Discs. Curves Comparing Copper Resistances—Rodman Testing Machine and Falling Weight. Data from General Abbot.

PLATE III.

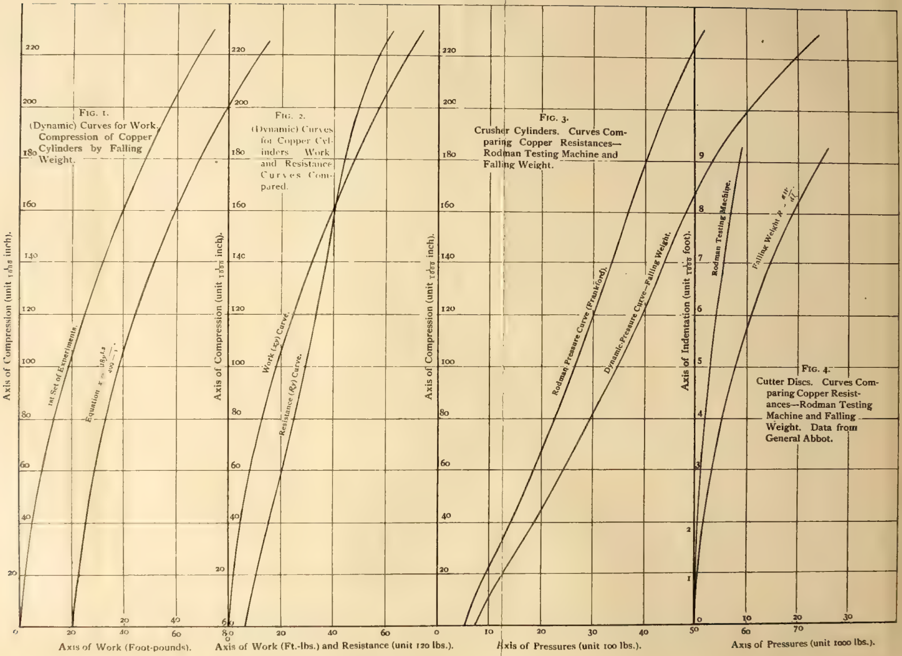


Fig. 1.
(Dynamic) Curves for Work. Compression of Copper Cylinders by Falling Weight.
1st Set of Experiments.
Fig. 2.
(Dynamic) Curves for Copper Cylinders Work and Resistance Curves Compared.
Work (xy) Curve.
Resistance (Ry) Curve.
Fig. 3.
Crusher Cylinders. Curves Comparing Copper Resistances—Rodman Testing Machine and Falling Weight.
Rodman Pressure Curve (Frankford).
Dynamic-Pressure Curve—Falling Weight.
Fig. 4.
Cutter Discs. Curves Comparing Copper Resistances—Rodman Testing Machine and Falling Weight. Data from General Abbot.
Rodman Testing Machine.
Axis of Compression (unit 1/1000 inch).
Axis of Indentation (unit 1/1000 foot).
Axis of Work (Foot-pounds).
Axis of Work (Ft.-lbs.) and Resistance (unit 120 lbs.).
Axis of Pressures (unit 100 lbs.).
Axis of Pressures (unit 1000 lbs.).

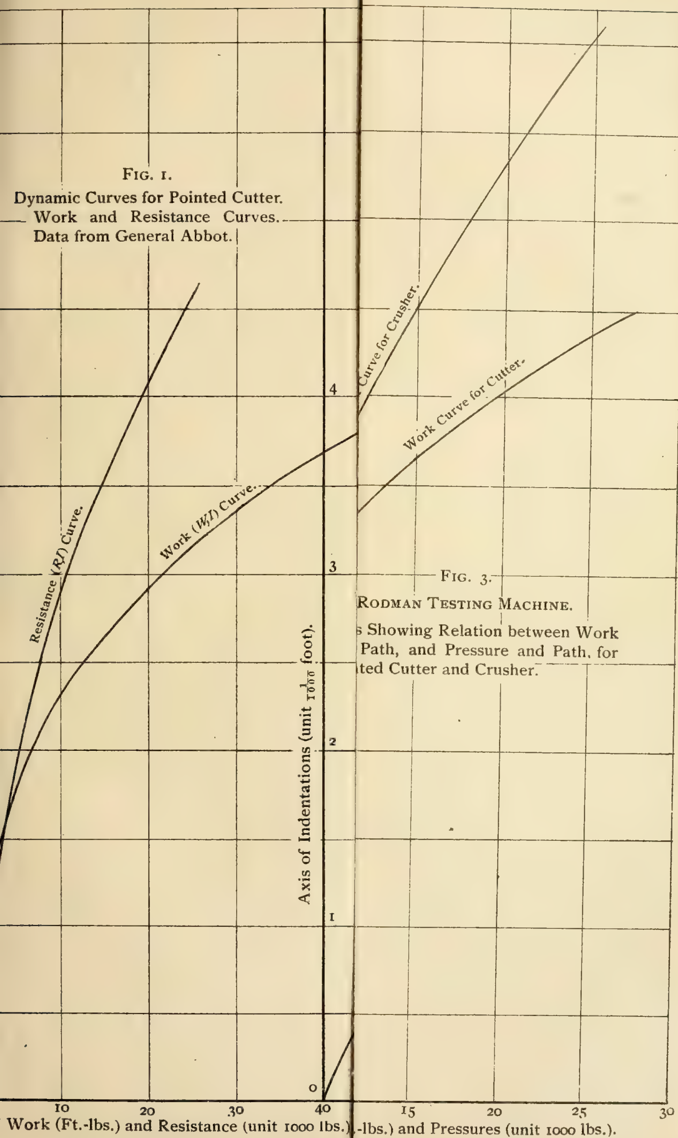


FIG. 1.
Dynamic Curves for Pointed Cutter.
Work and Resistance Curves.
Data from General Abbot.

FIG. 3.
RODMAN TESTING MACHINE.
s Showing Relation between Work
Path, and Pressure and Path, for
ted Cutter and Crusher.

PLATE IV.

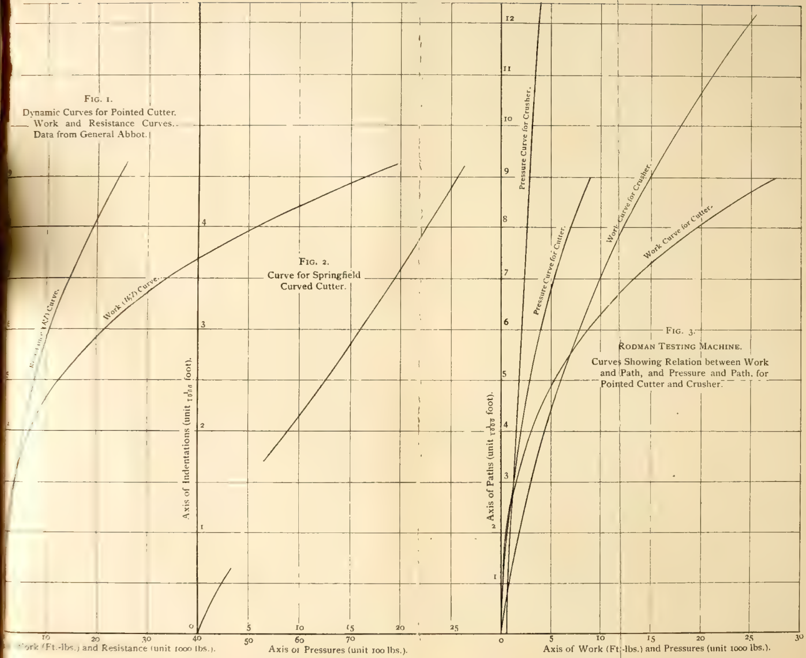


Fig. 1.
Dynamic Curves for Pointed Cutter.
Work and Resistance Curves.
Data from General Abbot.
Work (W) Curve.
Work (Ft.-lbs.) and Resistance (unit 1000 lbs.).
Fig. 2.
Curve for Springfield Curved Cutter.
Axis of Indentations (unit 1/1000 foot).
Axis of Pressures (unit 100 lbs.).
Fig. 3.
Rodman Testing Machine.
Curves Showing Relation between Work and Path, and Pressure and Path, for Pointed Cutter and Crusher.
Pressure Curve for Crusher.
Pressure Curve for Cutter.
Work Curve for Crusher.
Work Curve for Cutter.
Axis of Paths (unit 1/1000 foot).
Axis of Work (Ft.-lbs.) and Pressures (unit 1000 lbs.).

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

PIGEONS FOR SEA SERVICE.

WITH AN ACCOUNT OF THEIR USE DURING THE LAST SUMMER CRUISE OF THE U. S. P. S. CONSTELLATION.

By Assistant Professor H. Marion, United States Naval Academy.

Nearly all the European governments have recognized the value of homing pigeons for land and sea service, and have established numerous military pigeon posts in the interior and along the coasts, under direct control of the Government.

In France, Germany, Austria, Italy, Spain, and Portugal, the organization of military pigeon posts is very complete. It has been extended to Russia, Denmark and Sweden; and even Africa has been brought into communication with Spain by stations at Ceuta and Mellila. England has recently established a station of considerable strategical importance at Gibraltar, insuring communication with Tangier and vessels cruising in the vicinity of the Straits of Gibraltar. The chief columbary of the Admiralty is situated at the Scilly Islands.

Italy has been particularly active of late in establishing pigeon posts for naval purposes to be used in connection with the manœuvres of her new fleet. For example, there is a military pigeon post at Rome, and another at the Island of Maddalena, and the birds belonging to them alternately fly from one loft to the other in very good time. The total distance is 170 miles, and that over water 150 miles. These pigeons have flown on several occasions at the rate of 28, 29 and 30 miles an hour. A longer distance at sea haz also been made by them.

Another military loft is situated at Cagliari, Sardinia, which constitutes part of the Cagliari-Napoli line. The distance between those two places is 294 miles. Birds liberated at sea from Italian vessels have made a distance of as much as 287 miles over the sea at about 31 miles an hour.

Canada has followed the example of the European countries by establishing a connected system of pigeon stations throughout the Dominion, extending from Halifax to Windsor, and connecting her principal seaports with the interior.

The accompanying chart I., showing the system of military pigeon posts in Europe, gives an adequate idea of the importance of this new branch of the service. Each one of the lines upon the map shows a pigeon route. In most cases there is a double post, that is to say, there are relays of pigeons at each end of these lines, so that, by exchanging birds, a double service is insured. Other lines are still more perfected, the same birds performing a double duty, being used for a "there-and-back" flight.* The employment of pigeons for military purposes, therefore, may be considered as established, and the value of this service as no longer requiring to be proved.

We have frequently urged in these PROCEEDINGS (Nos. 47, 48 and 54) the adoption of a similar system at the principal seaports and naval stations of the Atlantic coast. So far no organized system of pigeon posts has been established in the United States, although numerous experiments made in this country have fully demonstrated the great value and usefulness of such a service, especially for naval purposes.

The most important of these experiments, and the most successful in its results, was made under the direction of Commander C. M. Chester, U. S. N., during the last summer cruise of the U. S. P. S. Constellation.

We quote, by permission, some extracts from the interesting and most carefully prepared report of Lieutenant W. S. Benson, U. S. N., who took an active part in the experiments.

"On June 6, the day the Constellation sailed from Annapolis, ten pigeons from the Naval Academy loft were taken on board and released at different distances down the Chesapeake Bay, the last at

*This remarkable result can only be obtained over short distances, not exceeding 50 miles, by long and careful training, feeding the birds at one end of the line, and keeping their mates and young ones at the other.

CHART I.

CHART SHOWING THE SYSTEM OF MILITARY PIGEON POSTS IN EUROPE.

[*Reproduced, by permission, from Mr. Tegetmeier's article in the Journal of the Royal United Service Institution, Vol. XXXVI, No. 171. Published originally in La Nature.*]

FRANCE.—I, Mont Valérien ; 2, Paris ; 3, Vincennes ; 4, Lille ; 5, Douai ; 6, Valenciennes ; 7, Maubeuge ; 8, Mézières ; 9, Verdun ; 10, Toul ; 11, Langres ; 12, Belfort ; 13, Besançon ; 14. Lyon ; 15, Marseille ; 16, Perpignan ; 17, Grenoble ; 18, Briançon ; 19, Toulon.

PORTUGAL.—1, Lisbonne ; 2, Porto ; 3, Valence ; 4, Chaves ; 5, Bragance ; 6, Almeida ; 7. Guarda ; 8, Coimbre ; 9, Castello Branco , 10, Abrantès ; 11, Elvas ; 12, Peniche ; 13, Beja ; 14, Lagos.

ESPAGNE.—1, Madrid ; 2, Figueras ; 3, Iaca ; 4, Pamplona ; 5, Oyarsun ; 6, Ferrol ; 7, Ciudad-Rodrigo ; 8, Badajoz ; 9, Tarifa ; 10, Ceuta ; 11, Melilla ; 12, Palma ; 13, Mahon ; 14, Zaragoza ; 15, Valladolid ; 16, Cordoba ; 17, Malaga ; 18, Valencia.

ITALIE.—1, Rome ; 2, Ancone ; 3, Bologne ; 4, Vérone ; 5, Plaisance ; 6, Alexandrie ; 7, Mont Cenis ; 8, Fenestrelle ; 9, Exîles ; 10. Vinadio ; 11, La Maddalena ; 12, Cagliari ; 13, Gaeta ; 14, Génova.

SUISSE.—1, Thun ; 2, Bâle ; 3, Zurich ; 4, Weesen.

ALLEMAGNE.—1, Berlin ; 2, Cologne ; 3, Metz ; 4, Mayence ; 5, Wurtzbourg ; 6, Strasbourg ; 7, Schwetzingen (en projet) ; 8, Wilhelmshaven ; 9, Tonning ; 10, Kiel ; 11, Stettin ; 12, Dantzig ; 13, Kœnigsberg ; 14, Thorn ; 15, Posen ; 16, Breslau ; 17, Torgau.

AUTRICHE.—1, Comorn ; 2, Cracovie ; 3, Franzenfeste ; 4, Karlsburg ; 5, Serajewo ; 6, Mostar ; 7, Trieste.

DANEMARK.—1. Copenhague.

SUÉDE.—Carlsborg.

RUSSIE.—1, Brest Litovsk ; 2, Varsovie ; 3, Novo-Georgievsk ; 4, Ivangorod ; 5, Luninetz.

a distance of 35 miles, and two and a half hours later the messages were received in Annapolis. One of these birds carried an important message to the Superintendent of the Naval Academy requesting that certain stores that had been omitted from the outfit be sent down to the ship by the Phlox.

"All of the birds liberated returned in good time, and all messages were safely delivered.

"On the return of the Constellation in August, some of these same birds were used at distances of 60 miles, in each case carrying important messages regarding the Constellation to the Superintendent. A few days later these same pigeons were liberated at a distance of 75 miles from Annapolis; all returned, delivering the messages sent in each case. Subsequently they were successfully used at a distance of 100 miles. Nine pigeons were taken on board June 6, belonging to the loft of R. B. Caverly, of Washington, D. C. They were liberated at points in the Chesapeake Bay, and at sea, the last batch being liberated in latitude 38° 6′ N., longitude 74° 10′ W. (180 miles from Annapolis, 200 miles from Washington). All of these pigeons returned to their lofts carrying messages.

"Previous to the departure of the Constellation from Newport on the return trip to Annapolis, in August, through the exertions of E. S. Starr, of Philadelphia, at the request of Professor Marion, pigeons were sent to the ship from lofts in Philadelphia, Woodberry, N. J., Atlantic City, Providence and Fall River. During the six days the vessel was at sea, several birds were liberated at 9 A. M. each day (except one when the weather was threatening, with a strong breeze from northward), bearing duplicate messages giving the ship's position, condition of weather for the past twenty-four hours, and other items of interest. In nearly every case these messages were delivered at the respective lofts the same day and the messages repeated to the Superintendent of the Naval Academy by telegraph. The greatest distance from land any birds were liberated was about 90 miles; and those liberated to the northward of their lofts had previously only been flown from the southward, and the owners were under the impression that they could be used successfully only from the southward. Their success showed that pigeons could be flown from *any* direction."

These results show that the pigeon service from *ship to shore* was entirely successful.

Another experiment in the opposite direction, namely, from *shore to ship*, was less conclusive, as the birds used in this experiment had been put on board at short notice and were not yet thoroughly domesticated when used. In spite of this disadvantage, some good, and even unexpected, results were obtained. We again quote from Lieutenant Benson's interesting report.

"Before leaving Annapolis, ten pigeons (also taken from the Naval Academy loft) were sent on board the Constellation and placed in a cote secured on the spar-deck capstan on the quarter-deck. Nearly all these were young birds, two only one month old. The cote was left closed until the 19th, when it was opened and all were allowed to fly about the vessel, then at anchor off New London. The pigeons flew about the Constellation, other vessels in the harbor, and on shore. Before night all had returned to the cote except two, one old, the other young. . . . After this the cote was opened every day when the weather was good, and in a very short time the pigeons became accustomed to the unusual noises of the people about decks, flapping of sails, wash-clothes, etc., and would return to the cote even when the awnings were spread which concealed the cote from view. Four of these birds were frequently taken ashore, out in boats, and to other vessels, and they always returned. They were taken from three to four miles over land and out of sight of the shipping and still returned. It was observed, however, that they did not always go directly to their own ship, but would light on other vessels near. On several occasions they were taken ashore and not liberated till the ship had left her anchorage and was *several miles out*, under sail and light yards down, and yet they got back in very good time."

This experiment, however limited in its scope, opens a new field for the usefulness of homing pigeons for naval purposes. They might be used, for instance, to carry news from a landing party to a vessel stationed or cruising at a short distance from the shore or for communications between the different vessels of a squadron.

In concluding his report Lieutenant Benson says:

"I beg leave to add that, from the successful employment of homing pigeons on land at all distances, and the work done by those on the Constellation, the conclusion must be accepted that their field of usefulness is unlimited. On land, where all points can usually be reached by telegraph, their employment is more in the

nature of a pastime; though under certain circumstances they might be of great value even on land [as, for example, during the siege of Paris]. But to the navy and seafaring people they are simply of inestimable value. The idea advanced in Professor Marion's paper* on the subject of establishing a regularly organized service with lofts at all our naval stations cannot be too strongly advocated. In order, however, to be successful, I am thoroughly convinced that the service must be well organized and the pigeons well trained. It is a well-known fact that the principal European governments not only have such a service, but offer every inducement to private enterprise in this direction. The frequent trips made by our different vessels along our coast offer every facility for training pigeons from all the various lofts that might be established. By sending a number of birds on every outward bound vessel the pigeons would have numerous flights over the routes for which they were intended, and could thus be relied upon in case of actual necessity, and the people using them would also gain experience in their use, which would be of no small importance; thus in time of peace giving them practice and training as well as often sending back valuable information. Their value in time of war cannot be estimated. Suppose, for example, that a small cruiser left one of our seaports and, off the coast, unexpectly sighted an enemy's fleet; eight or ten hours notice might be given, thereby saving millions of dollars worth of property as well as the ignominy of defeat.

"The most important fact to be remembered is that when these birds are properly trained and used under a well-organized system they offer an almost sure means of quick communication where none other could possibly be employed. In order to be satisfactory there must be a well-organized system, men who understand handling and breeding the birds, and the best means of sending messages. Every effort should be made to secure and breed the best birds only, and they should be constantly exercised over the route it is intended to use them on, so that no time will be lost when they bear important messages in working out the nearest line of flight.

"The fact having been clearly demonstrated that homing pigeons can be successfully employed to carry messages from vessels at sea to shore stations opens a field of usefulness to the naval service that is inestimable. The numerous ways in which they can be employed

*Proposed Naval Messenger Pigeon Service, No. 54, PROCEEDINGS NAVAL INSTITUTE.

is so apparent that it would be superfluous to dwell upon it in this report.

"As to their use in carrying messages from shore to vessels at sea there is not sufficient data to say positively how far they could be depended upon; but judging from what has been done, we are justified in believing that with proper training and care they could be fully relied upon as messengers."

The foregoing report has been strongly endorsed by Commander C. M. Chester, under whose direction these experiments were made, and he recommends that an appropriation be asked of Congress to carry out the proposed plan of such a service. No appropriation having having been available for this purpose in the past, the expense has been mainly met by private subscriptions, which are not likely to continue.

A system of naval messenger pigeon lofts to be situated at the principal navy yards and stations of the Atlantic coast could be established at a very small expense to the Government and would be of great practical value, even in time of peace, as vessels cruising along the coast from Portland, Me., to Galveston, Tex., could thus keep in constant communication with the mainland and be located at any time during their entire course.

We suggest a connected system of twelve main naval messenger pigeon lofts to be situated at the following navy yards and stations:

1. Portsmouth.
2. Boston.
3. Newport.
4. New London.
5. New York (Brooklyn).
6. Philadelphia (with an annex at Cape Henlopen).
7. Washington (Central Station).
8. Annapolis (Naval Academy).
9. Norfolk (with an annex at Cape Charles.)
10. Port Royal.
11. Key West.
12. Pensacola.

The greatest distance being between the last four stations, some intermediate posts would be desirable between them to insure a connected service. The system could be extended and completed by establishing secondary stations at Cape Hatteras, Wilmington, N. C., St. Augustine, Jupiter Inlet, and Tampa, Florida, and extreme stations at each end—Portland, Me., and Galveston, Tex.

Chart II. shows the position of the U. S. P. S. Constellation when birds were liberated during the last summer cruise. It also

shows the proposed naval messenger pigeon stations along the Atlantic coast with circles of 240 miles radius around each station, indicating the zone in which trained pigeons could be relied upon to return to their home station with a sufficient degree of certainty. The distance is equal to one day's run of a vessel making ten knots an hour, and it could be covered by a pigeon in about eight hours, at an average speed of 30 miles an hour, thus gaining 16 hours on the vessel. Although homing pigeons have flown twice that distance in a day, it is undesirable, for practical purposes, to exceed that limit. From these lofts a vessel leaving any of these stations could be supplied with trained pigeons to be liberated at intervals within the prescribed zone of the station to which they belong.

The message to be sent is written on fine tissue paper, which, rolled up, is inserted into a section of goose quill, then sealed at both ends and firmly fastened to one of the middle tail feathers of the bird by means of a thin copper wire.

To insure safe delivery, each message is duplicated, in cipher if necessary, and forwarded by two or more different birds, liberated at the same time, as they help each other in finding their way home. For long distance flights the birds must be liberated as early in the day as possible.

Advantages of an Organized Service of Messenger Pigeons.

A service of messenger pigeons for naval purposes could not be improvised at short notice, and the birds would require long and careful training before being of any use as bearers of messages.

In time of peace or war the occasions are innumerable when pigeons could be used with advantage as messengers when no other means of communication are available. In a recent article in Outing Mr. Gifford says:

"In peace vessels leaving or approaching the coast could report their own or the position of disabled vessels needing assistance; wrecks, broken machinery, mutinies, lack of food, water (or coal), fire, and thousands of accidents which are likely to happen to any ship at any time, could thus be made quickly known. It would in many instances influence the speculations of merchants, relieve the anxiety of ship owners and the relatives of sailors. They will then have no longer to resort to such uncertain means as signals, meeting of ships, or the floating bottles ashore with messages.

In war they would be of much greater importance. It is essential that the Government should always be able to locate exactly its ships. Great fights seldom occur more than two hundred miles from shore and thus valuable knowledge of skirmishes at sea and the approach of hostile forces and appeals for aid could quickly be communicated.''

In order that this service may be successful it must be operated by the Government.

The fact that homing pigeons can fly several hundred miles a day at sea; that they can be bred and trained on board ship in all latitudes and climates; that they can be accustomed to the report of guns; that they can recognize their own ship among others; that they can be relied upon, as proved by numerous experiments, to carry news from the fleet to the shore, and, under favorable circumstances, from the shore to the fleet and from one vessel to another, when beyond the range of signals, should suffice to secure the support of the Government to this new enterprise, and thereby insure the speedy establishment of a permanent system of naval messenger pigeon lofts at the principal navy yards and stations along the Atlantic coast.

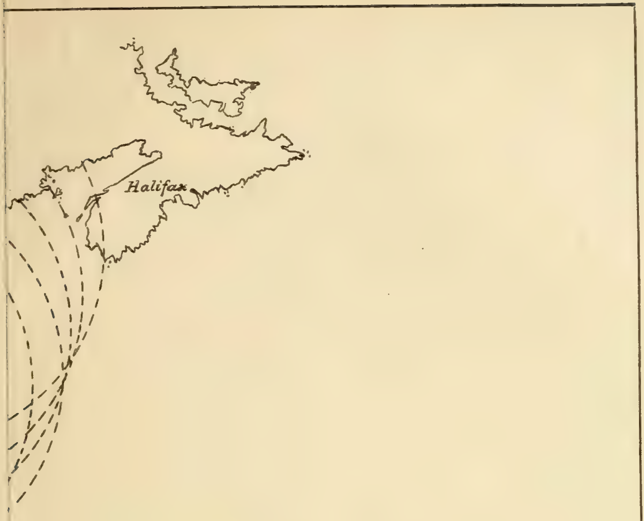

Halifax

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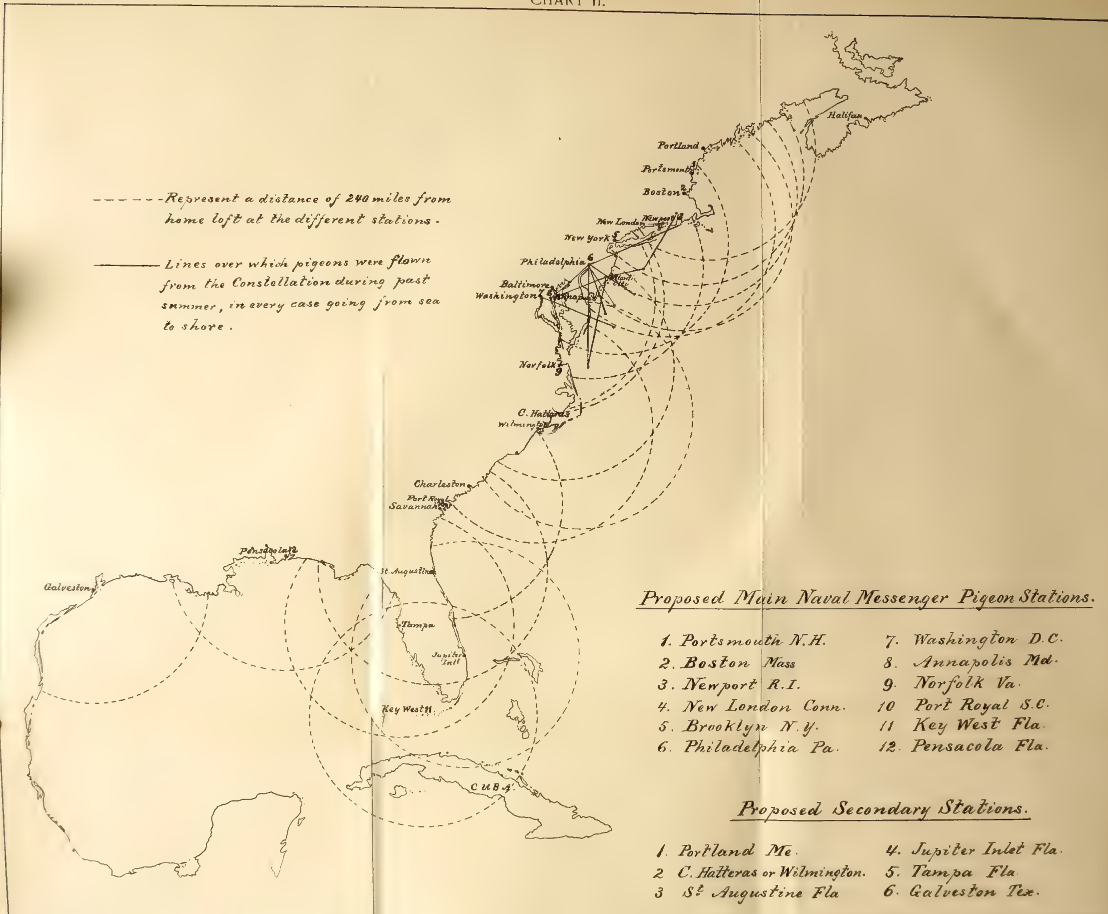
CHART II.



Represent a distance of 240 miles from home loft at the different stations.
Lines over which pigeons were flown from the Constellation during past summer, in every case going from sea to shore.
Portland
Portsmouth 1
Boston 2
New London
Newport 3
New York
Philadelphia 6
Baltimore
Washington 7
Norfolk 9
C. Hatteras
Wilmington
Charleston
Port Royal
Savannah
St. Augustine
Tampa
Jupiter Inlt
Key West 11
Pensacola 12
Galveston
Halifax
CUBA
Proposed Main Naval Messenger Pigeon Stations.
1. Portsmouth N.H.
2. Boston Mass
3. Newport R.I.
4. New London Conn.
5. Brooklyn N.Y.
6. Philadelphia Pa.
7. Washington D.C.
8. Annapolis Md.
9. Norfolk Va.
10 Port Royal S.C.
11 Key West Fla.
12. Pensacola Fla.
Proposed Secondary Stations.
1. Portland Me.
2 C. Hatteras or Wilmington.
3 St Augustine Fla
4. Jupiter Inlet Fla.
5. Tampa Fla
6. Galveston Tex.

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CASSIER'S MAGAZINE.

VOLUME II., No. 6. Electrical equipment of modern ships. Engine testing. Transmission of power. Steam and pressure gauges. Tandem compound engines.

No. 7. A test of multi-cylinder engines. The value of water power. Utilizing the power of ocean waves. Steam distribution in single-acting compound engines.

No. 8. Progress in generating high pressure steam. Direct connected engines. Compressed air. The measurement of power. A new independent condenser.

No. 9. Shipbuilding in America. Machine molding. Electrical equipments of modern war ships. Modern methods of storing coal.

No. 10. Steam and electric power. Direct connected engines. Mechanical methods of securing dry steam. Compound engine, with Proell's valve gear. Brayton petroleum engine. New machine tools.

J. K. B.

IRON AGE.

MAY 5, 1892. The manufacture of gun-cotton.

Description of the method employed at the U. S. Torpedo Station.

MAY 12. Balancing marine engines.

Paper read by A. F. Yarrow before the Institution of Naval Architects.

The submarine sentry.

Device for automatically indicating when a certain minimum depth has been reached.

MAY 19. Report of meeting of American Society of Mechanical Engineers.

Synopsis of papers and discussions. Among the papers is one upon the utilization of the power of ocean waves by Naval Constructor A. W. Stahl, U. S. N.

The Seller's turning and boring lathe for 16-inch B. L. R.

Description, with plates, of the machine made for the Washington navy yard.

MAY 26. United States ferry boat.

Description and drawings of the ferry boat for the navy yard, Portsmouth, N. H., particularly of the Towne boiler.

Attaching sea valves to hulls of double-bottom ships. Electric forging and tempering.

Drawings and description of apparatus.

Making projectiles for the Government.

Machinery and methods employed by the U. S. Projectile Co., of Brooklyn, N. Y.

JUNE 2. Japanese war vessels.

New additions to the Japanese navy.

JUNE 9. Breech mechanism for heavy guns.

Drawings and description of the breech mechanism of the 10″ and 12″ navy B. L. R.

Submarine torpedo-boats.

General account of results accomplished and description of the Baker boat, tested at Detroit, Mich.

JUNE 16. Recent development and progress of gun manufacturing in the United States; I., by W. H. Jaques, late U. S. N. The Mosher steam boiler.

Description and plates of a boiler designed for small vessels of high speed.

JUNE 23. Recent development and progress of gun manufacturing in the United States; II., by W. H. Jaques, late U. S. N. Microscopic structure of iron and steel, by P. Kreuzpointner (illustrated).

JULY 21. Firing the Justin projectile.

Experiments with projectiles loaded with explosive gelatine in shell guns.

AUGUST 18. Seabury's breech mechanism for rapid fire artillery.

Description of mechanism patented by Lieut. Seabury, U. S. N.

Fellows steam steering gear.

SEPTEMBER 1. Making great guns; shrinking on jackets and hoops.

Description of manufacture of 10″ rifle at the Watervliet Arsenal.

OCTOBER 6. Test of an Ellis-Tresidder compound armor plate at Shoeburyness.

OCTOBER 20. Electric motors in a machine shop. The Brown segmental wire gun.

Synopsis of paper read at the meeting of the American Institute of Mining Engineers, by N. B. Whitman.

OCTOBER 27. Random shop notes.

Method of removing hoop from built-up gun which had cooled before properly placed, by means of making a casting of iron around the exterior of the hoop and thereby expanding it.

NOVEMBER 3. Tool for boring breech-loading ordnance.

C. M. K.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

VOLUME IV., NO. 1. The U. S. S. S. Cushing and its experiments investigated. A study of the elements of a screw propeller. The failure of steel castings for U. S. steamship Maine and Cruiser No. 11. Bilge drainage. Notes: The Atlantic liners; D'Allest boilers; Defective boilers in English war vessels; Coal consumption in men-of-war; Basic Bessemer steel; Inspection of machinery afloat in British navy; Ships under construction at home and abroad.

NO. 2. Screw propellers of U. S. naval vessels. Method of moulding a cylinder at the Bath Iron Works. Transmission and distribution of power on modern ships. Electric pumping plant for salt water aquaria. Columbian Exposition. Proposed revision of rules of Steamboat Inspection Service. Balancing marine engines. Notes: Smoke; Navy boilers; Effect of depth of water on speed of ships; Serve boiler tube; Triple screws.

NO. 3. The chase of the Itata. Moulding and casting the cylinders of the Raleigh and Cincinnati at Brooklyn navy yard. Feed water heating. Comparison of the propellers of some U. S. navy ships. Proportioning riveted joints for boilers. Trial of the Ville de Douvres. Experiments with basic steel. Whaleback steamers. Notes: French naval contracts; Iron vs. steel boiler tubes; Normand's tubular boiler; Leaky boiler tubes; Harvey carbonizing process.

J. K. B.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

JULY, 1892. Smokeless powders. Prussian great general staff. Practical drill for infantry. Practical workings of rifle practice against an enemy.

The author dwells at some length on the evidently bad position of aim as laid down in the new Drill Book, that of the army being identical with the navy.

Civil war in Chile.

SEPTEMBER. Is the tendency of modern drill regulations salutary? The value of manœuvres and Kriegs-spiel. The physical training of the enlisted man.

NOVEMBER. Guns and forts. Our new infantry drill regulations.

F. J. H.

JOURNAL OF THE UNITED STATES ARTILLERY.

JANUARY, 1892.

The first number of this Journal is temporarily edited by First Lieutenant W. B. Homer, First Lieutenant H. C. Davis, First Lieutenant J. W Ruckman, First Lieutenant C. DeW. Willcox, and Second Lieutenant L. G. Berry, all of the U. S. Artillery. The Journal will be published quarterly by the Artillery School Press, of Fort Monroe, Virginia.

The effect of wind on the motion of a projectile.

A mathematical deduction of the deflections, retardations and accelerations given to a projectile by the influence of the wind, including formulæ and tables, showing method for calculation of such deflections.

The determination of the velocities of projectiles by means of sound phenomena (continued). Our artillery organization. Range tables for the 12-in cast iron B. L. mortar. The Chilian navy.

APRIL. Sea coast guns and steel armor.

After thoroughly discussing the probable conditions that would exist in the event of a fort being attacked by iron-clads, the author arrives at the conclusions that the largest gun thus far designed, the XVI.-in. B. L. R., will be too small to penetrate the heaviest armor of the heaviest battle-ships ; that the VIII.-in. B. L. R. should be lengthened to 50 calibres in order to pierce the light side armor of iron-clads, and that the X.-in. and XII.-in. B. L. R. can be used against the light side armor. The minimum range used is 4000 yards, and it seems unfortunate that the discussion was not brought to 1500 yards, which in all probability would be somewhat nearer the range the battle-ship would seek, especially if the motion of the ship was sufficiently great to make it necessary to come close in order to get a steadier platform, and to insure greater accuracy.

Notes on field practice. Notes on the English proving ground at Shoeburyness. The determination of the velocities of projectiles by means of sound phenomena (concluded).

JULY. Theoretical instruction of gunners.

A detailed system of daily instruction for enlisted men and non-commissioned officers, covering the ground necessary that they become thoroughly proficient in the handling of ballistic formulæ. As an illustration of the necessity of such knowledge an example of a four-gun battery being attacked by a squadron. The captain desires certain information, and after finding the range, by means of a range finder, asks of his first sergeant : "What is the normal elevation for that range?" The sergeant *calculates* or consults a table previously calculated, etc.

If the sergeant has a range-table it requires no knowledge of ballistic formulæ to be able to run down the table to the range, and abreast of it find the angle of elevation. If the captain is going to stop to have the range calculated, applying the barometer and thermometer, the ship will be nowhere near where where it was when the range was first given by the time the calculation is finished. Knowledge of the use of ballistic formulæ might be desirable, but hardly essential to the proper performance of the gunner's duties.

A study of the effects of smokeless powder in a 57 mm. gun. Department of Chemistry and Explosives of the U. S. Artillery School. The effect of accelerating and retarding winds upon projectiles. A proposed design for a new ballistic target.

OCTOBER. Electricity and the art of war. Recoil of heavy guns and its control. Time fuse with Shrapnel fire. F. J. H.

JOURNAL OF THE UNITED STATES CAVALRY ASSOCIATION.

JUNE, 1892. Snap shooting with the rifle and pistol. Gymnasiums and riding halls at cavalry posts. F. J. H.

ORIGINAL PAPERS ON DYNAMO MACHINERY AND ALLIED SUBJECTS. By John Hopkinson, M. A., D. Sc., F. R. S. New York: The W. J. Johnston Co., 1893. 249 pages. Price, $1.00.

The collection in one volume of all of Dr. Hopkinson's excellent papers on electro-technical subjects will be highly appreciated by electrical engineers and others interested in the theory and use of dynamo-electric machinery.

The first three papers are on electric lighting; the fourth and fifth upon the theory and design of continuous-current dynamos. In these five papers the characteristic curves of dynamos and efficiency experiments are ably discussed.

There are also five interesting papers on alternating currents and converters.

Recent graduates of the Naval Academy will find this book interesting and profitable. N. M. T.

RAILROAD AND ENGINEERING JOURNAL.

JULY, 1892. The cruiser Chicago. Columbian exposition notes. A process for wood preservation. A light-draft stern-wheel steamboat. Two-cylinder versus multi-cylinder engines. Aluminum and its uses. The Almy tubulous boiler. Steel stern-frame casting for the Marblehead. The Baker submarine boat.

SEPTEMBER. The Watervliet gunshop. Electric safety signals. The battle-ship Royal Sovereign. The future developments of electric railroads. The Nicaragua Canal. U. S. naval progress. Columbian Exposition notes.

OCTOBER. The Krag-Jorgensen repeating rifle. The Belpaire boiler. An oil-burning furnace. The battle-ship Barfleur. U. S. naval progress. J. K. B.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MINING ENGINEERS.

VOLUME XX. The alluvial tin deposits of Siak, Sumatra. Explosions from unknown causes. Chinese silver mining in Mongolia. A compound plunger hydraulic pump. Sampling ores without use of machinery. The first American blast furnace. The physical and chemical equations of the open-hearth process. Aluminium in steel ingots. International standards for the analysis of iron and steel. Electricity in welding and metal working. American blast furnace practice. Manganese in cast iron. Apparatus for the manipulation of iron and steel plates during the process of finishing. The handling of ingots and moulds in Bessemer works. Electric loco-

motives in German mines. The fuel supply of the United States. Results of stream measurement of U. S. Geological Survey. Notes on sampling iron ores. The utilization of anthracite waste.

J. K. B.

FOREIGN.

Alloys of Iron and Chromium. By R. A. Hadfield. Reprint from the Proceedings of the Iron and Steel Institute, received by the Naval Institute through the courtesy of Captain E. L. Zalinski, U. S. A., Associate Member.

The recent remarkable development of the steel industry of the United States in its application to warlike material—a development which has been effected largely by study of special alloys of iron in which the action of carbon is modified by the presence of other substances—gives to this paper by Mr. Hadfield a peculiar timeliness. The striking improvement in armor, due to the addition of a small percentage of nickel, has been paralleled by an almost equally striking improvement in projectiles, resulting from the use of manganese and chromium. Chrome steel, which is now used by most of the leading firms of the world for armor-piercing projectiles, was, as Mr. Hadfield is careful to acknowledge, first manufactured on a practical scale in this country, the present Chrome Steel Company, of Brooklyn, being the pioneers in its development. Its first application for armor-piercing projectiles was in the case of a 6-inch shell manufactured and tested, with remarkable results for that period, at the Naval Ordnance Proving Ground at Annapolis, by the recent chief of the Naval Bureau of Ordnance.

The celebrated Holtzer projectiles owe their excellence, at least in part, to the use of this alloy, to which also Mr. Hadfield attributes much of the important success which his firm has recently had in producing high-grade projectiles for the English government. Photographs accompanying the present paper show very strikingly the extent of this success, and leave no room for doubt that chromium is an important factor in the manufacture of steel for purposes where it is important to secure a high tensile strength and elastic limit and great hardness without the sacrifice of elongation, at the expense of which these qualities are usually obtained.

Mr. Hadfield's experiments make it clear that chromium, *per se*, does not give hardness, nor does it in any other manner take the place of carbon. Its function, like that of silicon, manganese, aluminum and nickel, in the cases where these are alloyed with iron and carbon, is to *assist* the carbon, not to replace it.

It appears clearly, also, that the value of the chromium depends greatly upon the percentage of carbon present, the effect of its addition to low steels being hardly perceptible.

With regard to the nature of its beneficial effects upon high steels, the author does not speak with much confidence. He considers, however, that it certainly assists the hardening action of the carbon in tempering, and that, to some extent, it plays the part of a hardener without the interposition of a cooling medium. The paper gives interesting details of the history of the metal chromium since its discovery at the end of the last century, and of the process of combining it with steel. A. M. K.

ALMANACH DER KRIEGSFLOTTEN.

Part I., 1892. Tables of weights and measures, and reduction tables for the English and metric systems.

Part II. Armament of the different fleets.

Tables of 1891 revised and based upon the latest data.

PART III. List of vessels of the world.

Giving dimensions, horse-power, armor, armament, speed, material and date of launching. Also one hundred and forty-three cuts of armored ships, with alphabetical list of same.

The Austrian navy in the East Indies.

An account of the extended cruises of the Austrian men-of-war Nautilus and Aurora, in the East Indies, from 1884–1888, based upon the reports of the commanders of these vessels, supplemented by consular and other authentic reports, by Commander V. Benko. H. O.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

XXTH ANNUAL SERIES, VOLUME I. Report on the tests of running lights on board ship, by Prof. Dr. Seaward Weber, of Kiel. Deep sea soundings in the Indian Ocean. . The Argentine territory in Terra del Fuego. Remarks on the harbor of Constitution, Chile, by Captain Rötger, of the German navy. Remarks on the sailing directions of the harbor of Mollendo, Peru, by Commander Kirchoff, of the German navy. Remarks on the islands Anno Born, Banana and Mossamedes, west coast of Africa, by Commander v. Dresky, of the German navy. Report of Captain I. G. Nichelson, of the German bark Theodore; voyage from Liverpool to Callao; Callao harbor; route from Callao to the northern ports of Chile; voyage from Iqueque to Falmouth. Observations on the harbors of Corinto and Venadillo, west coast of Nicaragua, by Captain Rikert, of the German bark Caroline Behn. The chart of magnetic declinations, by Prof. Dr. G. Neumayer, of Hamburg. Minor notices: The passage of the German ship Urania, Captain Gahde, through the Straits Le Maire, en route from New Castle to Valparaiso; Sudden changes in the temperature and weather off Cape Guardafui, east coast of Africa; On the driving ashore of sea birds in storms; Tables.

VOLUME II. Remarkable storms; the storms of November 11th and December 11th, 1891, and those from the 5th to the 7th of January, 1892, by Prof. W. J. Van Bibber. The difference of temperatures of air and water in the China Sea and adjacent waters, by Captain G. H. Seemann. Remarks on Batonga, Gaborn, Anno Born and St. Thomé, by Lieutenant Commanding Goecke, commanding the German gunboat Hyäne. The use of oil to quiet the sea. Guayaquil and Callao; extracts from the cruising report of Captain C. Oltman, of the German bark Pacific. Voyage from the Straits of Sunda to Singapore, thence to Pulo Penang; extracts from the report of Captain C. Sauder, of the German bark Standard. The comparison of Beaufort's scale with the velocity of the wind. Minor notices: Rat Island, Houtman Abrolhos, west Australia; The pilot system of Townsville, Queensland; peculiar cloud formation experienced by the steamer Sophie Rickmers, in the bay of

Bengal; the charges of the Newcastle Tugboat Company between Sydney and Newcastle, N. S. W.; The weather on the German coast in January, 1892; Tables.

VOLUME III. A new method of finding longitude by star observations, by H. Florian, of Vienna. A study of fog-signals, by Prof. Dr. Mohn, of Christiania. Remarks on the harbor of Chang Tau, Chusau Islands, from a report of Lieutenant Commanding Muller, of the German gunboat Iltis. Hydrographic observations on the Gulf of Guinea, from a report of Lieutenant Commanding Goecke, of the German gunboat Hyäne. Report on Callao, Corinto and La Union, by Captain Green, of the German bark Elizabeth. Report on Guaymas, Santa Rosalia and Cape Horn, by Captain Burmester, of the German bark Guaymas. Report of Captain A. Schulz, of the German bark Julio Theodoro. The use of oil to quiet the sea. Bottle-post; records of bottles thrown overboard and picked up. Minor notes: Correct longitude of Suez; The hurricane of August, 1801, at Martinique; New nautical and hydrographic publications; Weather on the German coast in February, 1892; Tables.

VOLUME IV. A study of fog-signals, by Prof. Dr. Mohn, Christiania (conclusion). Report on the determination of the length of the simple seconds pendulum and specific gravity constants at Hamburg, by A. Mohlke. On the appearance of electrical phenomena around Cape Horn, between 50°–60° S. lat. and 90°–80° W. long., by Captain H. Haltermann. Voyage of the German frigate Leipsic, Captain Rötger, from Valparaiso to Montevideo. Voyage of the German man-of-war Moltke, Captain v. Erhardt, from Bahia to Port Spain, Trinidad. Report of Captain Haase, of the German ship Kepler, on harbor of Chittagong. Voyage of the German ship Kaiser, Captain R. Alberts, from Singapore to Besuki and Pasumau. Voyages of the German ships Adolph, Captain Westergaard, and Gustav and Oscar, Captain Seemann, from Hong Kong to and through the Straits of Sunda, Esmeraldas, Ecuador. Report of Captain Dreyer, of the German schooner Neptune. Minor notes: Weather on the German coast in March, 1892; Tables.

SUPPLEMENT. A method to calculate the time of high and low water at any place, by Prof. C. Börgen.

VOLUME V. Report of the German naval observatory on the results of magnetic observations on the coast of Germany in 1891. Magnetic observations on the coast of the Adriatic in 1889, 1890, by direction of the Marine Department of Ministry of War, of Austria. Contributions to the knowledge of the wind and weather in the vicinity of Cape Horn, from observations between 1882–1891, by Captain H. H. Haltermann, assistant in the Naval Observatory. Report of Captain Köller, of the German bark Freya, on Guayaquil, Esmeraldas and Manta. Report of Captain Kuhfal on the harbor of

Mayaguez, Porto Rico, and the hurricane of September 19 and 20, 1891. Minor notes: Ice in the vicinity of Cape Horn; Red color of the sea and the whales of the Indian Ocean; The weather on the German coast in April, 1892; Tables.

VOLUME VI. Remarks on the great circle sailing charts on gnomonic projection, recently issued by the U. S. Hydrographic Office, by Dr. Meyer, Professor in the University of Kiel. Contributions to the knowledge of the wind and weather in the vicinity of Cape Horn (continuation). Roth Island: SW. coast of Timor I. The Mauritius hurricane of April 29, 1892. Hydrographic information in regard to several ports on the west coast of South Africa; also in regard to currents experienced on the passage from Cape Town to the Cameroon, by the German gunboat Hyäne, Lieutenant Commanding Platche. Information in regard to the harbor of La Guayra, and the approach to Aux Cayes, Hayti, from the report of Captain Erhardt, of the German man-of-war Moltke. Voyage from Apia to the Gilbert and Marshall Islands, from the report of Commander Fischer, of the German cruiser Sperber. Sailing along the coast of Ecuador, from the report of Captain Frerichs, of the ship Aeolus. Weather on the German coast in May, 1892, with tables. A chart of the drift ice off the coast of Newfoundland, from the middle of February to the early part of June, 1892.

VOLUME VII. Drift ice in southern latitudes, from December, 1891, to May, 1892. Conclusion of contributions to a knowledge of the wind and weather around Cape Horn, etc. Report on the fifteenth competitive test of marine chronometers in the winter 1891–92, made at the Naval Observatory at Hamburg. Voyage of the German man-of-war Leipsic, Captain Rötger, from Cape Town to Zanzibar via Port Elizabeth, Delagoa Bay, Mozambique, Luidi, Kilwa Kiwinji and Dar es Salam. Report on the sailing directions for, and the bouyage in the channel of, the harbor of Mozambique, by Captain Frantzius, of the German navy. Remarks on the sailing directions for, and on the harbor of, English River, Delagoa Bay, by Commander Kirschoff, of the German navy. Sailing directions for Wentchau, by Lieutenant Commander Muller, commanding German gunboat Iltis. Hydrographic notes on the west coast of South Africa, by Commander Hessner, of the German navy. Currents between Camaroon and Loando, west coast of Africa, from the report of Commander Goecke, of the German navy. Minor notes: Peculiar thunder-storm experienced by the German steamer Flandria, Captain Hahn, on the voyage from St. Thomas to Hamburg; Illuminated clouds observed by Captain Kühlewein, of the German steamer Albingia, on the voyage from St. Thomas to Havre; The weather on the coast of Germany in June, 1892; Tables; A chart of the approach to Wentchau.

VOLUME VIII. Description of an apparatus to determine the

error of the sextant due to eccentricity, by C. Koldewey, of the German Admiralty. The Samoan hurricanes of February and March, 1889, with five charts and one diagram, by E. Knipping, formerly Director of the Observatory of Tokio. The tracks of hurricanes in the South Indian Ocean. The submarine sentry, a sounding machine, invented by Samuel H. James, to indicate the depth of water at any moment without delaying the vessel. Voyage from Newcastle, N. S. W., to Mazatlan, and thence to Salina Cruz and neighboring ports, from the report of Captain Blanke, of the German bark Marseille. Somabaya, passing through Torres Straits to the westward, from the report of Captain Hendorff, of the German bark Werner. Drift ice in the South Atlantic Ocean. Sailing directions for the Indian Ocean issued by the German Naval Observatory. Minor notes: Meteors; Time signal at Lussinpiccolo; Waterspout experienced by the German ship Columbus, Captain Sauermilch, on the voyage from Cardiff to Singapore; The weather on the coast of Germany in July, 1892; Tables. H. O.

BOLETÍN DEL CENTRO NAVAL.

FEBRUARY, 1892. Trials of the Canet gun of 32 cm., 40 caliber, mounted in barbette towers. The coasts of Patagonia.

MARCH–APRIL. Specialties in the navy; mode of recruitment. Modern constructions; plans of a rapid cruiser for the Centro naval. The Montes' artificial horizon. Report of the Board appointed to prepare a new plan of organization and course of studies for the naval school.

MAY. A voyage to Tierra del Fuego, related by Commander O'Connor. J. L.

DEUTSCHE HEERES-ZEITUNG.

MAY 7, 1892. The past and present character of small-arm targets.

MAY 11. French fortifications.

MAY 14. The progress of the German field-telegraph system. The question of cavalry-fire in Russia.

MAY 18. The military organization of the Russian railroad service during peace.

MAY 21. March of an army corps.

MAY 25. The fifth international conference of the Order of the Red Cross.

MAY 28. The military bicycle service of France.

JUNE 1. Targets for battle practice in the German army. Remarks on types of modern war-ships. Distribution of naval forces in European waters.

JUNE 4. The new regulations for infantry-fire of the Italian army. Distribution of the naval forces in European waters (continuation).

JUNE 11. The colonial military force of Holland. Distribution of the naval forces in European waters.

JUNE 18. The officers of the Turkish army.

JUNE 22. The tests of the 12 cm. of 40 calibers, and the 15 cm. of 15 calibers, Krupp rapid-firing guns. The coast defences of France.

JUNE 25. The attack and defence of modern armored fortifications.

JUNE 29. The attack and defence of armored fortifications (conclusion).

JULY 2. The term of service of the French army. The Italian mountain troops.

JULY 6. The English and Russian military strength in Asia. The Italian mountain troops (conclusion).

JULY 9. The Chinese army.

JULY 13. The small caliber rifle in the civil war in Chile, 1891.

JULY 16. The field-gun of the future and the criticism of the present. Military balloon service.

JULY 20. Military balloon service (continuation).

JULY 23. The warrant for a one-year volunteer service. Military balloon service (conclusion).

JULY 30. The German military train.

AUGUST 10. The training of the infantry recruits of the German army. The French manœuvres for 1892.

AUGUST 17. The question of target or field practice. Changes in the battle tactics of infantry due to the introduction of small-caliber rifles and smokeless powder.

AUGUST 24. Dried vegetables and corn coffee as provisions for an army. The French manœuvres, 1892. The reorganization of the Bulgarian army. What practical lessons have we for a naval battle at the end of the 19th century?

AUGUST 31. The French manœuvres of 1892. What practical lessons have we for a naval battle at the end of the 19th century (continuation)?

SEPTEMBER 7. Krupp and Canet. Change in the character of the British war-ships on foreign stations between July, 1891 and 1892. What practical lessons have we for a naval battle at the end of the 19th century (continuation)?

SEPTEMBER 14. What practical lessons have we for a naval battle at the end of the 19th century (conclusion)?

SEPTEMBER 21. The two-years term of service a necessary consequence of universal military duty. The storming of Ismail on Dec. 22, 1790.

SEPTEMBER 24. The French manœuvres of 1892. The storming of Ismail on Dec. 22, 1790 (continuation).

SEPTEMBER 28. A criticism of the new pontoon-service regulations of the German army. The storming of Ismail (conclusion).

H. O.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXVI., NO. 171, MAY, 1892. Pigeons for land and sea service.

A paper of interest in view of recent experiments on the Constellation during the past summer, and in connection with the papers by Lieutenant Niblack and Prof. Marion in this issue of the PROCEEDINGS.

Atlantic weather and its connections with British weather. The Royal Naval Exhibition of 1891. The defensive strength of Russia. The naval schools of the chief continental powers (continued).

NO. 172, JUNE. Military geography.

A short but interesting article on the broad principles of the subject, illustrated by references to the frontier defenses of European countries as affected thereby.

Electricity as applied to torpedo and other naval purposes. Military education. The place and uses of torpedo-boats in war.

This paper is by Mr. Laird-Clowes, and is essentially the prize essay of the U. S. Naval Institute for the current year. It is quite fully discussed by a number of officers of experience in the handling and management of torpedo-boats. The discussion develops many points in which the practical men take issue with the lecturer, and the whole is worth serious study by our own officers, who have practically nothing of personal experience to aid them in forming their opinions on this important subject.

Professor Frölich's new method for determining the velocity of a projectile in the gun (trans.). The naval schools of the chief continental powers (concluded).

NO. 173, JULY. Modern aërial navigation.

This very interesting lecture, by Captain Fullerton, R. E., is written from the standpoint of the modern scientific inquirer, and presents the latest ideas on the subject. The possible military changes that would result from success in this line are briefly touched upon, but the lecturer leaves the reader to judge for himself of the practicability of any or all of the systems of flight mentioned.

Discussion on the subject of the naval prize essays. Combined tactics. Précis of the instructions for gunnery and torpedo schoolships of the Italian navy.

No. 174, AUGUST. Ambulance work and matériel in peace and war. The dimensions of modern war ships.

In this lecture Captain Eardley-Wilmot advocates battleships of moderate displacement, from 9000 to 10,500 tons, to form the bulk of the fleet. He thinks it practicable, in view of recent improvements in armor, to limit its thickness to 12 inches; the speed of battle ships need not be very great, but the coal capacity should be, and the torpedo equipments very complete. In arguing for moderate, as against great displacement, he considers the time and and cost of construction, the lighter draught and greater docking facilities, the influence of the ram and torpedo, and the strategical advantages of being able to cover a wider extent of sea or coast, and of being able to detach small squadrons without unduly weakening the main body. For cruisers, he considers the proper size about 4000 tons, is opposed to any considerable weight of armor, is in favor of a not too heavy armament. He argues that the heavy gun, if permissible at all, should be a stern, not a bow chaser, and insists on a great coal endurance as a vital point.

Experiments at Spandau to illustrate the penetration of German rifles (trans.).

A contribution to the literature of the effect of modern high-power, small calibre rifles.

No. 175, SEPTEMBER. Magazine rifles.

Captain James, in this very interesting paper, lays down the six principles upon which the ideal rifle should be constructed, as follows:

1. The bolt should have a rectilinear motion, because that enables the soldier to fire without taking the rifle from the shoulder.

2. The magazine should be central, and should hold ten or twelve cartridges.

3. The cartridges should be contained in a frame, or filler, so that they can be rapidly loaded into the magazine.

4. The cartridges should be easily taken from the holder for use in the weapon as a single loader.

5. There should be a cut-off, which should be so arranged as to facilitate the use of the weapon as a single loader.

6. The bore should be sufficiently small to enable a long bullet to be driven at a high velocity, so that at medium ranges, *i. e.*, within 800 yards, one sight will suffice for military purposes.

Captain James argues in favor of these several points, and continues with a discussion of the various weapons forming the armament of the different European powers. He then discusses (*a*) the effects produced by the modern military rifle upon troop formations, and (*b*) the physical effects of the bullets on the human frame, and concludes with a series of tables showing the present armament of European armies, latest pattern magazine rifles, the penetration of modern rifles, and a list of foreign surgical works dealingwith the effects of small bore rifles upon the human frame.

Torpedo net defenses (trans.).

A very good argument against the use of nets in any case. "In our opinion the torpedo catchers and torpedo-boats are, as yet, the best means of protection against the insidious attacks of their companions."

No. 176, OCTOBER. Colonel von Löbell's Annual Report upon the changes and and progress in military matters in 1891. The French naval manœuvres. The field-gun of the future. H. S. K.

MILITAR WOCHENBLATT.

MAY 11, 1892. Krupp rapid-fire guns.

A brief description of the guns of larger calibre, those of 12, 15 and 16 c. m., with a comparison table of these guns with those of Armstrong, Hotchkiss and Canet.

Manual of the organization of the French army.

A brief review of the book.

MAY 21. The fortifications of Constantinople.

JUNE 1. A review of the latest discoveries and inventions in the military and technical fields. The Danish navy.

JUNE 4. A contribution to the study of field-guns of the future, and especially of a rapid-firing gun.

JUNE 8. Tests of hard bread in France.

JUNE 11. Review of the latest discoveries and inventions in the military and technical fields (conclusion).

JUNE 18. The new Belgian infantry rifle. The improved Mauser gun adopted for the Belgian infantry.

JUNE 25. The English battleship Royal Sovereign.

JULY 2. The Sims-Edison torpedo (from the Engineer).

JULY 9. Remarks on the use of the sword and fire-arms in the War of Secession in the United States, 1861–65. The raising of a sunken coal steamer. A short account of the raising of coal steamer in Wurla Roads, Gulf of Smyrna, by the crew and with the appliances of H. M. S. Edinburgh.

JULY 30. Submarine guns in the United States.

AUGUST 10. The training of infantry in fire practice.

AUGUST 13. The new Mauser repeating rifle for Turkey, Argentine and Spain.

SEPTEMBER 3. Armor tests in the United States. The naval policy of the United States.

SEPTEMBER 24. The wound of the Mannlicher rifle. Attack on coast defenses.

SUPPLEMENT.

NO. 2, 1892. The winter campaign of 1807 in Prussia, by Captain Grauert, of the German general staff. Blücher's campaign against Lübeck in 1806, by Major Beseler, of the German general staff.

NO. 3. The British naval manœuvres in 1891, by Captain Stenzel, of the German navy. The conscription under Napoleon I., by Col. von Lettow-Borbeck, of the German army.

No. 4. The study of the wars of Frederick the Great in their relation to the modern art of war, by Major F. von Bernhardt, of the German general staff.

No. 5. Military events of the civil war in Chili in 1891, by Captain Schaumann, of the German army. The training of cavalry for reconnaissance service.

Nos. 6 and 7. The service of the 5th Cavalry Division of the German army in the days between the 10th and 16th of August, 1870. H. O.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

Volume XX., No. 1. The reorganization of the Austrian-Lloyd S.S. Co. The development of the torpedo-boat; translation of the article on the subject by Lieutenant R. Hunt, U. S. N., begun in Naval Progress, 1801. Rapid-firing guns of large calibre (continuation). The guns manufactured by the Société Anonyme des Forges et Chantiers de la Méditerranée. Tests of armor plates in England and North America; an account of the tests of plates treated by the Tressider process and of those by the Harvey process. The high-speed gunboat built for Costa Rica by Yarrow & Co. The new English auxiliary cruiser Ophir. Nickel steel for shipbuilding. The Brazilian torpedo-boats Marcilio, Dias, Ignatemy and Araguay. Petroleum as fuel. Rust protection for iron and steel wire. A new paint. Captain Garciuts' method of using oil at sea.

Nos. 4 and 5. The belligerents' rights on the sea in the Chilian Civil War of 1891. Continuation of article on rapid-firing guns of large calibre—guns manufactured at the Krupp establishment The system of coast defence in European countries, by Lieutenant C. C. Rogers, U. S. N. The English naval budget for 1892–93. The attack of coast defences by a naval force, by Captain H. J. May, of the English navy. The telegraphic machine for ships of V. Schuckert & Co., of Nuremberg. The use of aluminium in the construction of yachts. The budget of the German navy 1892–93, and the fleet neceessary for service in 1892–93. The new French torpedo-boats Eclair, Orage and Kahyle. The French torpedo-cruisers of the Bomb class. The American monitor Miantonomoh. The trial of a special Chamon armor plate. The endurance of English guns of large calibre. Ballistics of smokeless powder, manufactured by Krupp. Trials of submarine guns in Italy. The English torpedo-boat Vulcan. The Italian torpedo-cruiser Urania. Bohmayer's electric gong. The union of the Caspian and Black seas by canal. Trials of anchors at Portsmouth, England. The use of carrier pigeons at sea. Franklin's life buoy. The trials of the Sims-Edison torpedo in the United States. The Sims-Edison electric life-boat.

Nos. 6 and 7. A new coast chart of the Adriatic, by Lieutenants Duger and Nappes of the Austrian navy. Probable influence of rapid-firing guns upon naval tactics and shipbuilding, by Rear Admiral Long, of the English navy. The system of coast defences of Europe, by Lieutenant C. C. Rogers (conclusion). The use of liquid fuel on board men-of-war, by George Herbert Little. Remarks on manageable torpedoes. The vibration of ships and the use of balanced machinery. The budget of the Italian navy, 1892–93. Comparison of the ballistic data of the 10, 12 and 14 c. m. Spanish rapid-firing guns, with the guns of Armstrong, Krupp, Hotchkiss and Canet, of the same calibre. In the military top of a modern battleship or cruiser. The Italian battleship Sardigna. The launching of the French battleships Bouvines and Jemmapes. The new French battleship Massena, building at the works of the Société des Chantiers de la Loire. Launching of the English cruiser Crescent. The use of cellulose in the U. S. navy. The establishment of a training-ship to qualify men in the use of rapid-firing guns. The effect of lightning on board ship, and the use of conductors. Liquid fuel for torpedo-boats. Budget of the Russian navy, 1892. The manufacture of cordite. A submarine boat for diving purposes. The Italian torpedo-cruiser Urania; a description of the vessel. The submarine gun in America. A floating net to quiet the sea, invented by Baron d'Alessandro; trial of the same in France. The submarine boat of George C. Baker. The English battleship Royal Sovereign.

Nos. 8 and 9. The methods of the so-called new nautical astronomy, in its historical development and with regard to its practical applicability. Rapid-firing guns of large calibre—the guns manufactured by the Maxim-Nordenfelt Gun and Amunition Co., Limited (continuation). Budget of the French navy, 1893. A new Normand torpedo-boat. Regulations of the French navy for the preservation of boilers. The accident to the boilers of the French armored cruiser Dupuy de Lôme. The introduction of steel wire hawsers in the French navy. The launching of the German dispatch-boat, Hohenzollern. New vessels for the Argentine navy. The U. S. gunboat Castine. Pilots for torpedo-boat service in the French navy. The Siamese yacht and cruiser Maba Chackrkri. The whaleback steamer Charles W. Wetmore. Description of the submarine boat of George C. Baker. A miss-fire of an automobile torpedo; showing the danger of these weapons and the necessity of care in the use of them. The trials of short launching-tubes for torpedo. New warships for Brazil, building at the Armstrong works at Newcastle. Trial of the battery of the English turret-ship Abyssinia. 1000 m. initial velocity obtained with Canet 57 m. m. The Grenfell illuminated sights for great guns; trial of the same in England. The trials of the heavy guns of the French battleship Neptune.

SUPPLEMENT.

Report of magnetic observations on the coast of the Adriatic, made by direction of the Marine Department of the Ministry of war of Austria, conducted by Commander Franz Laschober, assisted by Lieutenant Kesslitz, of the Austrian navy. A text-book on electricity for non-commissioned officers, especially as applied to use on board of warships, by M. Burstyn, marine and electrical engineer.

H. O.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS.

February, 1892. Notes on the mechanical features of the Liverpool water works. On the disposal and utilization of blast furnace slag.

May. Report upon the trial of the Ville de Douvres.

Since their last report the Research Committee on marine engine trials have been enabled to carry out a trial on a large paddle steamer, the Ville de Douvres. A full description of the trial is given with the results, to which is appended the tabulated data showing the comparative results of the trials of the five screw steamers previously tested.

On condensation in steam engine cylinders during admission.

In this paper the author gives the results of some experiments on the steam engine with the object of determining the amount of loss by condensation in the cylinder as distinguished from the liquefaction necessarily caused by the performance of work, and embodying them in the shape of approximate formulæ for determining the condensation under given conditions.

J. K. B.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

June, 1892. Notes on applied field fortification.

Some useful hints in regard to the selection of position according to the nature of the ground; the disposition of general and battalion officers, and of the different lines of troops; and the methods of defense and precautions to be taken to prevent night attacks.

Notes of lectures on artillery in coast defence. Fire tactics.

This chapter on fire tactics embraces eight general rules for the character of the fire to be used in forts against armored vessels, and is preceded by general remarks on the character of the different classes of ships of some of the foreign navies (continued).

July. Battle of the velocities. Notes of lectures on artillery in coast defence—Fire control, Fire discipline.

This chapter includes illustrative tables showing at what points to attack certain classes of vessels, correction tables for tide, and a diagram giving penetrations of different English projectiles in wrought iron.

August. Fire discipline; its necessity in a battery of horse or field artillery, and the best means of securing it. (The Duncan gold medal prize essay for 1892.)

SEPTEMBER. Fire discipline. (The silver medal prize essay.)

OCTOBER. The U. S. Military Academy at West Point. Fire discipline. (Commended essay, 1892.) F. J. H.

REVISTA TECNOLÓGICO INDUSTRIAL.

APRIL, 1892. Resisting strength of materials.

A study of trials of iron and steel.

MAY. A floating derrick of 80 tons. Resistance of materials.

JUNE. A new phase in aluminium; its alloyage. The Munier multiple telegraph type writer.

A full description of the apparatus is given.

JULY. A new phase of the metal aluminium; its alloys, etc. (ended). Resistance of materials, etc. (continued). J. L.

REVUE MARITIME ET COLONIALE.

JUNE, 1892. A study of the mechanical theory of heat. Problems of the British Empire (continued). Progress made in artillery during the year 1890.

A very interesting article.

Long aërial voyages; air balloons and exploration of the African continent.

JULY. Historical studies upon the military marine of France.

The article deals with the French navy before and during the Seven Years' War.

A study of the mechanical theory of heat. The English fleet off the coasts of Aunis and Saintonge in 1757. A vocabulary of powders and explosives (continued). Distribution of the small planets between Mars and Jupiter. Long aërial voyages, etc. (continued).

AUGUST. Origin of the French East India establishments. A vocabulary of powders and explosives (continued). The former marine corps of the French navy, 1622–1792.

SEPTEMBER. Statistics of shipwrecks and other maritime disasters for the year 1890. Origins of the French East India colonies; Ján Begum (Mme. Dupleix); 1706–1756. Historical studies of the military marine of France; the French navy before and during the Seven Years' War (continued). Long distance aërial voyages; aërostats and the exploration of the African continent. Naval chronicles.

OCTOBER. Among the Kanaks of New Caledonia. Long distance aërial voyages, etc. Origins of the French East India colonies, etc. (continued). Statistics of shipwrecks and other maritime disasters for the year 1890 (ended). Geometry of naval tactics; fourth series. A study of the mechanical theory of heat (continued).
J. L.

REVUE DU CERCLE MILITAIRE.

May 8, 1892. Works of the Geographical Service in France and Algeria, 1890–1891. The "lava" of the Cossacks.

Lava is an eastern expression representing a converging effort from circumference to centre and has no relation to volcanic lava. This peculiar mode of fighting of the Cossack is described at length through several numbers of the Revue and forms an interesting reading.

The use of the railways during the Turko-Russian war.

May 15. Works of the Geographical Service in France and Algeria during the years 1890–1891 (ended).

May 22. The different routes from the coast into the interior of Morocco. The English torpedo-boats.

June 12. Projected formation of a reserve of Algerian "tirailleurs." The lines of penetration into the interior of Morocco (ended).

June 19. The Royal Sovereign. A reserve of Algerian "tirailleurs."

June 26. The Austro-Hungarian army regulations.

July 3. A study of Dahomey (with map). The English navy and Parliament. The fortifications of Switzerland.

July 10. The first engagements of the army of the Rhine (1890), from the personal notes of an officer.

Continued in several numbers of the Revue.

July 24. The Division ambulance.

Aug. 28. The new drill regulations for the German army. The division army ambulance. The pneumatic gun in the United States. The first engagements of the army of the Rhine (Franco-German War).

September 4. The technical troops of the Austro-Hungarian army (engineer corps, pioneer and railway-telegraph regiments).

September 11. The Dauteteau rifle, caliber 6.5 mm. The technical troops of the Austro-Hungarian army (continued). The Russian naval manœuvres of 1892.

September 25 and October 2. The Divisions of the reserve at the manœuvres of 1892. The Chinese army of the green standard.

J. L.

THE STEAMSHIP.

May, 1892. The action of the screw and hydraulic, or jet, propeller. A computation of Joule's equivalent. The Institution of Naval Architects (reviewed elsewhere).

June. Captain Weir's azimuth diagram. The future of cast steel. The engines of the U. S. S. S. Monterey. Flexible metallic

tubing. The uses of asbestos in marine engineering. The first-class protected cruiser Gibraltar.

JULY. An improved steam engine governor. Air required for combustion. The new battleship Resolution. Forced blast oil-firing system.

AUGUST. Communication between stranded ships and the shore.

Illustrations and description of a rocket grapnel, to the inventors of which was awarded the prize offered by the London Graphic for the best means of establishing communication between stranded ships and the shore.

The question of lubrication. Indicator diagrams. Inclined triple expansion engines. The dimensions of modern warships. Pitting in boilers. The modern marine boiler. Petroleum steamers; their design and construction.

OCTOBER. Stockless anchors. Indicator diagrams. Corrugated furnaces. The treatment of marine boilers. Modern systems of refrigeration on ships. J. K. B.

TRANSACTIONS OF THE INSTITUTION OF NAVAL ARCHITECTS.

VOLUME XXXIII., 1892. Recent progress in warship construction, by Sir Nathaniel Barnaby. On the alterations in the types and proportions of mercantile vessels, together with recent improvements in their construction and depth of loading, as affecting their safety at sea, by B. Martell. Some notes on the history, progress and recent practice in marine engineering, by A. J. Durston. Progress in marine engineering in the mercantile marine, by A. E. Seaton. Summaries of the alterations and improvements in naval architecture and marine engineering in the English navy and merchant marine, as illustrated by the Naval Exhibition, the cause of this progress and the reasons for the survival of existing types. Center and wing ballast tank suctions in double-bottomed vessels, by G. R. Brace. On the weak points in steamers carrying oil in bulk, and the type which experience has shown to be most suitable for this trade, by George Eldredge. On divisional water-tight bulkheads, as applied to steamers and sailing vessels, by B. Martell. Notes on experiments with inflammable and explosive atmospheres of petroleum vapor, by J. H. Heck. Discussion of important subjects concerning the merchant marine. On steadying vessels at sea, by J. I. Thornycroft. On balancing marine engines, and the vibration of vessels, by A. F. Yarrow.

These well-known torpedo-boat builders, after stating the causes of rolling and vibration, explain their solutions of the different problems involved in overcoming these defects in small vessels. The former, with a short-period pendulum and a series of electro-magnets, automatically controls a hydraulic ram, which manœuvres a heavy weight athwartships, so that it moves downwards as the vessel inclines, thus reducing the right-

ing moment and the stability. The apparatus was tried in rough weather at various times on the yacht Cecile, and it was found that the angle of rolling was reduced from 18 degrees to 9 degrees. The author remarks that the half motion deducted from the rolling was much the worse half.

Mr. Yarrow shows that the true cause of vibration is due to the moving parts of the machinery; their momentum is accompanied by an equal momentum of the ship in an opposite direction. The correct method of overcoming the vibration is to design engines completely balanced in all directions during all phases of a revolution by the use of weights so situated that their momentum is at all times equal and opposite to that of the rotating, and particularly the reciprocating parts of the engine.

Notes on some recent experiences with H. M. ships, by W. H. White.

A summary o the official trials of the various types of the 70 English warships authorized in 1889, with discussions as to the effect of the depth of water on speed, vibrations at high speed and the advantages of using mild steel in hull construction, as illustrated by the mere local injuries caused by the grounding of the Victoria.

A ram vessel, and the importance of rams in war, by Commander E. B. Boyle, R. N.

Advocates the use of a double-ended ram having four rudders, with a screw at each extremity.

Whaleback steamers, by F. C. Goodall.

Discusses the advantages and disadvantages of this well-known type of American cargo carriers, and proposes certain improvements.

On an approximate rule for the vertical position of the centre of buoyancy, by S. W. F. Morrish.

Explains a rule which has previously been discovered by M. Normand, the famous French torpedo-boat builder.

Some notes on the strength of steamers, by A. Denny.

Presents a set of interesting tables showing variations of stresses in vessels of various forms under different conditions of loading.

On the transverse stability of ships, and a rapid method of determining it, by W. Hok.

Explains a new and rapid method for working out curves of stability.

On the theoretical effect of the race rotation on screw propeller efficiency, by R. E. Froude. On convenient curves for determining the most suitable dimensions for screw propellers, by R. E. Froude. On some additional features in the "Constant" notation used at the Admiralty Experimental Works, by R. E. Froude.

Short but valuable papers by the well-known experimentalist.

Performance of three sets of engines belonging to the second-class cruisers recently added to H. M. Navy, as calculated from the full power steam trials, by J. G. Liversidge.

An analysis to ascertain the causes of the varying efficiencies of different engines.

W. J. B.

TRANSACTIONS OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

VOLUME XLI., PART I. Experiments with explosives. Notes on the products and temperature of denotation of some high explosives.

PART II. Notes on an electric pumping plant. The practical transmission of power by electricity.

PART III. An inquiry into the cause of two colliery explosions.

PART IV. The detonation of high explosives by percussion. The iron ores of Spain. J. K. B.

LE YACHT.

JUNE 11, 1892. Remarks on the naval budget. The new battle-ships to be fitted with triple screws; the reason thereof. Review of the paper by Mr. Geo. Quick, of England, published in the U. S. Naval Institute Proceedings, concerning the increasing need for competent engineers on board men-of war. The cyclone of Mauritius; a relation by the commander of the Pei-Ho.

JUNE 25. Lord Brassey's Naval Annual. The torpedo-cruiser Wattignies.

JULY, 2. Trials of the Schneider rapid-firing gun of 15 cm. History of the gradual development of yachting. Vibrations of steam vessels.

JULY 30. Evolutions of the English fleet. Optic firing.

"This is a bright invention whose use has been recommended recently by a board of naval officers, and may be the prelude of a revolution in naval construction." The inventor, Commander de Fraisseix, of the French navy, has attempted to solve the problem of pointing heavy guns by using the principle of the photographer's camera. Stated briefly, his method of procedure was as follows: He inserted a lens in the place of the fore-sight, substituted for the back-sight a screen of white cloth, as being less fragile than the roughened glass of the photographer, and arranged a sort of camera by means of dark curtains of a flimsy fabric in such a manner that the image of the object of attack is cast on the screen, where the gunner watches it at his ease. A telemetric scale provides for the variation in position of the apparatus to accord with the distance of the object aimed at. The thing is extremely simple, and absolutely accurate, the gunner having the advantage of the extreme accuracy of the lens, which is of primary importance in firing at long range.

The optic sight was first tried in 1878, on board the school-ship Souverain. During, and since 1890, it has been repeatedly and successfully tried on the St. Louis, Duguesclin, Hoche, Courbet, and finally on the Achéron. At each trial the officers declared that the invention possessed mathematical precision, that it was simple and easy of manipulation, and did not require expert gunners, and was far superior to the ordinary way of pointing a gun.

The War Department has also experimented with it in the armored turrets of the advance works of fortified places. The commission in charge of the trial was not at first favorably disposed; but it stood the tests so successfully that a revulsion of sentiment in its favor took place, and it met with hearty approval.

In addition to the advantages already cited, this method of sighting possesses another of great importance. With it the gun-ports need be only sufficiently large to provide for the train of the gun, and thus additional protection to the crew may be gained. This consideration is of great importance in *any* case; and, in the case of turrets, might be a determining factor in deciding between open and closed turrets. After a six months' trial on board the Achéron, the board expressed the unanimous opinion that optic sighting should be adopted on all battleships fitted with closed turrets, and further recommended that measures be taken to provide all vessels in course of construction with closed turrets in anticipation of the installation of optic sights.

AUGUST 6. The French naval manœuvres. The aluminum yachts on the Lake of Zurich (with plates).

AUGUST 11. Aluminum construction, its probable developments and advantages.

"With the exception of three yachts at Zurich, one Swedish lifeboat, and a cutter in course of construction in England, we are not aware of any aluminum boats in existence. . . . It is certainly a remarkable fact that in three distinct places in Europe, far remote from one another, the same bold and somewhat hasty experiment has been made at the same time. In our opinion, this curious coincidence is not an exclusive proof of anxious desire for new inventions, but rather goes to show that the era of wood and iron in boat construction is passing away. . . . The cost of aluminum will gradually get lower and lower, owing as much to competition as to the general use of the metal in all kinds of industries; and inevitably, the advantages it presents in naval construction will by degrees make up, and more, for the extra outlay. These advantages are specially important from the triple point of view of lightness of hull, inalterability, and a great percentage of saving in the intrinsic value of the principal material. This saving is due to the remarkable simplicity and low cost of the metallurgy of aluminum, a simple re-melting restoring to it all its value. This is not so with ordinary constructions of wood or iron; hence the excess in the cost of aluminum shipbuilding is greatly diminished. It is, indeed, evident that if from the sum total expended on an aluminum vessel during its existence be deducted the value of the old material, that is, a great portion of the primitive material of the hull, the excess in the cost of the first purchase will be almost blotted out. The inalterability of the metal, which may be affirmed to be absolute, at least in regard to contact with air and fresh water, contributes also to a reduction in the cost, since it does away with paintings or coatings of all kinds, and allows of a great saving in the care and preservation of the vessel.

"The important point, in fact the reason for adopting aluminum in shipbuilding, is the extreme lightness of hull obtainable by the use of this metal. All navy people know full well the importance of reducing to a minimum the weight of the hull. In a vessel this weight is, so to speak, a dead weight, reducing in proportion the allotment for the engines, and diminishing the speed, coal endurance, and the mercantile or military worth of the ship. Now, in the small craft referred to as already built, the weight of the hulls is less than one-half and even two-fifths of the hulls of similar ones built of wood.

"Without insisting upon the good results likely to follow the introduction of the new metal in the construction of large vessels, which, in the present stage, might seem premature, it is nevertheless easy to demonstrate that the considerable reduction in the weight of hull affects many other small boats besides yachts. We will mention particularly the boats carried by large yachts and vessels-of-war and lifeboats. Boats in actual use—whaleboats and the like—are always too cumbrous. They burden the vessel,

not only with their own weights, but with the often more important ones of their hoisting apparatus, davits, winches, blocks, tackles, and all the fastenings they necessitate. Any decided diminution in the weight of such boats tends, therefore, towards a simplification of gear, and a corresponding decrease in the weight of their fixtures. In many cases the savings thus obtained would balance the extra costs of the boats.

"On the other hand, their tightness would not be impaired, as happens after a very short time with wooden boats, nor would they need the tedious care necessary to preserve sheet-iron boats from oxidation.

"Finally, a most important point: such boats could, with far more facility than ordinary boats, be fitted with air compartments, which would render them absolutely unsinkable. The latter advantage is of utmost importance in lifeboats." J. L.

August 20. The French naval manœuvres.

The theme prepared by the Admiralty for the Channel Squadron, embraced attacks upon the ports of Brest, Cherbourg and Havre. The most important point was to test the efficiency of the semaphoric service; the results were satisfactory.

August 27. The commercial naval schools: Report of the committee.

September 3. The coast defense sectors (apropos of the late naval manœuvres).

The coasts of France are divided into fifteen sectors, Two armored coast-guards and an indefinite number of torpedo-boats patrol each sector in case of war, or during mobilization in time of peace. In his article the author suggests changes tending to improve the service.

September 10. Our armament of rapid-firing guns. The Dutemple boiler.

September 17. The festivities in honor of Christopher Columbus. The Russian naval manœuvres.

September 24. The Board of General Inspectors, and the High Council of the Navy. The U. S. Cruiser Columbia.

October 6. The new organization of the naval reserve. The Russian manœuvres in the Black Sea. J. L.

EXCHANGES, BOOKS AND PERIODICALS RECEIVED.

American Chemical Journal.

Annual of the Office of Naval Intelligence, Gen. Inf. Series, No. XI.

Annual Report of the Postmaster-General.

Annual Statistical Report of the American Iron and Steel Association.

Bulletin of the American Geographical Society.

Bulletin of the American Iron and Steel Association.

Colliery Engineer.

Electrical Review.

ELECTRICITY AND MAGNETISM, by Edwin J. Houston. The W. J. Johnson Co., New York.

ENGINEER, New York.

ENGINEER, London.

ENGINEERING.

ENGINEERING—MECHANICS.

ESSAYS OF THE DEPARTMENTS OF ARTILLERY AND MILITARY SCIENCE, U. S. Artillery School, Class of 1892.

HAND-BOOK OF THE U. S. S. PHILADELPHIA.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

JOURNAL OF THE FRANKLIN INSTITUTE.

JOURNAL AND PROCEEDINGS OF THE UNITED SERVICE INSTITUTION OF NEW SOUTH WALES.

LOS ORIJENES DE NUESTRA MARINA MILITAR, by Admiral Luis Uribe Orrego, of the Chilean Navy.

MAGNETIC OBSERVATIONS OF THE UNITED STATES NAVAL OBSERVATORY, 1891–1892.

METEOROLOGICAL OBSERVATIONS OF THE UNITED STATES NAVAL OBSERVATORY, 1883–1887, 1888.

MEMOIRES DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

MINERAL RESOURCES OF THE UNITED STATES.

MODERN GUNS AND SMOKELESS POWDER, by Arthur Rigg and James Garvie. Spon & Chamberlain, New York.

NORSK TIDDSKRIFT FOR SOVAESEN.

OBSERVATIONS MADE DURING THE YEAR 1888 AT THE UNITED STATES NAVAL OBSERVATORY.

ONE HUNDRED AND FIFTIETH ANNIVERSARY OF THE FOUNDING OF THE FIRST CORPS OF CADETS, MASS. VOL. MILITIA.

PROCEEDINGS OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES.

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS.

RAILROAD GAZETTE.

REPORT ON SOME OF THE MAGNETIC OBSERVATORIES OF EUROPE, by Ensign C. C. Marsh, U. S. N.

REPORT OF THE INDIANA ENGINEERING SOCIETY.

REVISTA MARITIMA BRAZILEIRA.

REVISTA MILITAR DE CHILE.

RIVISTA DI ARTIGLIERIA E GENIO.

RIVISTA MARITTIMA.

SCHOOL OF MINES QUARTERLY.

STEVENS INDICATOR.

TEKNISK TIDSKRIFT.

THÉORIE DU NAVIRE, by J. Pollard and A. Dudebout Gauthier. Villars et Fils, Paris.

TIDSKRIFT SJOVASENDET.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

TRANSACTIONS OF THE CANADIAN INSTITUTE.

TRANSACTIONS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

Transactions of the Institution of Civil Engineers.

Transactions of the North-East Coast Institution of Engineers and Ship-Builders.

Transactions of the Technical Society of the Pacific Coast.

United Service.

United Service Gazette.

Western Soldier.

REVIEWERS AND TRANSLATORS.

Lieutenant Hugo Osterhaus,
Lieutenant A. M. Knight,
Ensign F. J. Haeseler,
Ensign C. M. Knepper,
P. A. Engineer J. K. Barton,
Asst. Nav. Constructor W. J. Baxter,
Professor N. M. Terry,
Professor Jules Leroux,
Lieutenant H. S. Knapp.

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1893.

Elected at the regular annual meeting, held at Annapolis, Md., October 28, 1892.

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* Declined. LIEUTENANT HUGO OSTERHAUS was elected to fill the vacancy.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1894.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the Prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1894. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

2. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

H. S. KNAPP,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *January* 3, 1893.